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(54) Title: HETEROCYCLIC COMPOUNDS AND THEIR USE (57) Abstract The present invention relates to therapeutically active azacyclic or azabicyclic compounds, a method of preparing the same and to pharmaceutical compositions comprising the compounds. The novel compounds are useful in treating diseases in the central nervous system caused by malfunctioning of the muscarinic cholinergic system.		

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Title**Heterocyclic Compounds And Their Use**Field of the Invention

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The present invention relates to therapeutically active azacyclic or azabicyclic compounds, a method of preparing the same and to compositions for pharmaceutical or veterinary use comprising the compounds and a carrier therefore. The novel compounds are useful as stimulants of the cognitive function of the forebrain and hippocampus of mammals and especially in the treatment of Alzheimer's disease.

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Background of the Invention

Due to the generally improved health situation in the western world, elderly-related diseases are much more common now than in the past and are likely to be even more common in the future.

20

One of the elderly-related symptoms is a reduction of the cognitive functions. This symptom is especially pronounced in the pathophysiological disease known as Alzheimer's disease. This disease is combined with, and also most likely caused by, an up to 90% degeneration of the cholinergic neurons in nucleus basalis, which is part of substantia innominata. These neurons project to the

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prefrontal cortex and hippocampus and have a general stimulatory effect on the cognitive functions of the forebrain as well as of hippocampus, namely learning, association, consolidation, and recognition.

5 It is a characteristic of Alzheimer's disease that although the cholinergic neurons degenerate, the postsynaptic receptors in the forebrain and hippocampus still exist. Therefore, cholinergic agonists are useful in the treatment of Alzheimer's disease, in halting its
10 progression, and in improving the cognitive functions of elderly people.

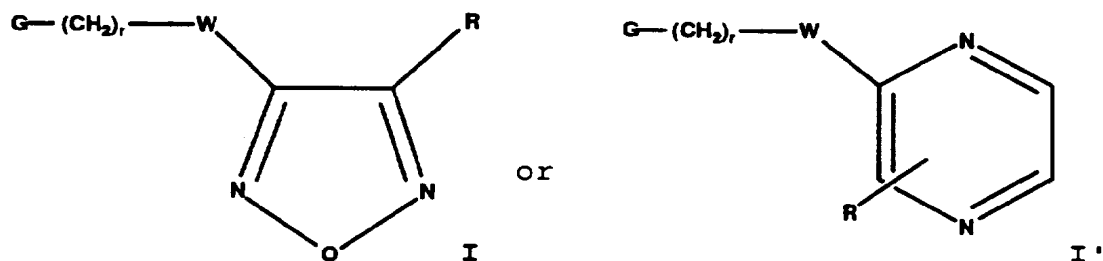
The compounds of this invention are also useful analgesic agents and therefore useful in the treatment of
15 severe painful conditions.

Furthermore, the compounds of this invention are useful in the treatment of glaucoma, psychosis, mania, bipolar disorder, schizophrenia or schizophreniform conditions, depression, sleeping disorders, epilepsy, and
20 gastrointestinal motility disorders.

Summary of the Invention

It is an object of the invention to provide new muscarinic cholinergic compounds and nicotinic cholinergic
25 compounds.

The novel compounds of the invention are heterocyclic compounds having the Formula I or I'



30 wherein

W is oxygen or sulphur;

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R is hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-\text{OR}^4$, $-\text{SR}^4$, $-\text{SOR}^4$, $-\text{SO}_2\text{R}^4$, C_3 - 10 -cycloalkyl, C_4 - 12 -(cycloalkylalkyl), $-\text{Z}-\text{C}_3$ - 10 -cycloalkyl and $-\text{Z}-\text{C}_4$ - 12 -(cycloalkylalkyl) wherein R^4 is C_1 - 15 -alkyl, C_2 - 15 -alkenyl, C_2 - 15 -alkynyl, each of

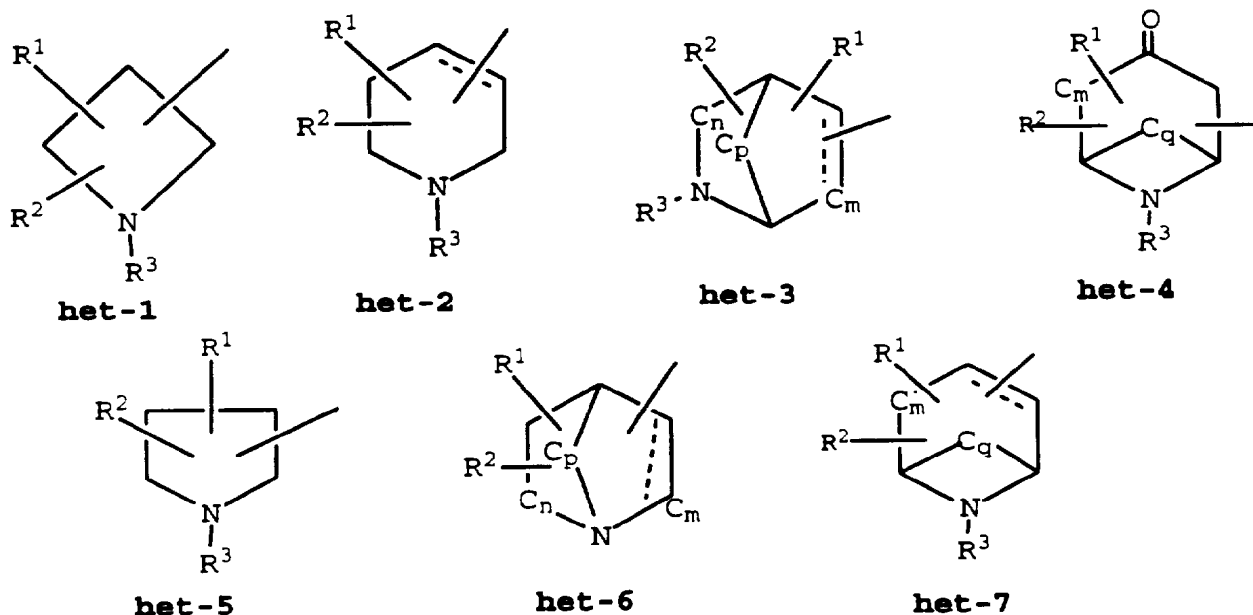
5 which is optionally substituted with one or more halogen(s), $-\text{CF}_3$, $-\text{CN}$, Y, phenyl or phenoxy wherein phenyl or phenoxy is optionally substituted with halogen, $-\text{CN}$, C_1 - 4 -alkyl, C_1 - 4 -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ or $-\text{CSNH}_2$; or

10 R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with halogen, $-\text{CN}$, C_1 - 4 -alkyl, C_1 - 4 -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ or $-\text{CSNH}_2$; or

R is $-\text{OR}^5\text{Y}$, $-\text{SR}^5\text{Y}$, $\text{OR}^5-\text{Z}-\text{Y}$, $-\text{SR}^5\text{ZY}$, $-\text{O}-\text{R}^5-\text{Z}-\text{R}^4$ or $-\text{S}-\text{R}^5-\text{Z}-\text{R}^4$ wherein Z is oxygen or sulphur, R^5 is C_1 - 15 -alkyl, C_2 - 15 -alkenyl, C_2 - 15 -alkynyl, and Y is a 5 or 6 membered

15 heterocyclic group; and

G is selected from one of the following azacyclic or azabicyclic ring systems:



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or G can optionally be substituted C₃-C₈ cycloalkyl or optionally substituted C₁-6-alkyl wherein the substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are hydrogen, C₁-6-alkyl; or

5 R⁶ and R⁷ together with the nitrogen atom optionally form a 4- to 6-member ring;

R¹ and R² independently are hydrogen, C₁-15-alkyl, C₂-5-alkenyl, C₂-5-alkynyl, C₁-10-alkoxy, C₁-5-alkyl substituted with -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, or
10 phenyl;

R³ is hydrogen, C₁-5-alkyl, C₂-5-alkenyl or C₂-5-alkynyl;

R^{6'} is hydrogen, C₁-6-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

15 p is 0, 1 or 2;

q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond; or a pharmaceutically acceptable salt or solvate thereof.

20 It is to be understood that the invention extends to each of the stereoisomeric forms of the compounds of the present invention as well as the pure diastereomeric, pure enatiomeric, and racemic forms of the
25 compounds of Formula I and I'.

Detailed Description

As used herein the term "treating" includes prophylaxis of a physical and/or mental condition or
30 amelioration or elimination of the developed physical and/or mental condition once it has been established or alleviation of the characteristic symptoms of such condition.

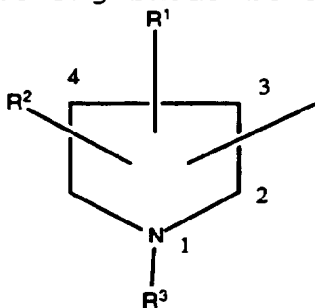
35 As used herein with reference to the G substituent, the -(CH₂)_r-W-oxadiazole or -(CH₂)_r-W-pyrazine

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moiety can be attached at any carbon atom of the azacyclic or azabicyclic ring. Further, R^1 and R^2 of the G
5 substituent may be present at any position, including the point of attachment of the $-(CH_2)_r$ -W-oxadiazole or $-(CH_2)_r$ -W-pyrazine moiety.

Examples of pharmaceutically acceptable salts include inorganic and organic acid addition salts such as
10 hydrochloride, hydrobromide, sulphate, phosphate, acetate, fumarate, maleate, citrate, lactate, tartrate, oxalate, or similar pharmaceutically-acceptable inorganic or organic acid addition salts, and include the pharmaceutically acceptable salts listed in Journal of Pharmaceutical
15 Science, 66, 2 (1977) which are known to the skilled artisan. The compounds of this invention may form solvates with standard low molecular weight solvents using methods known to the skilled artisan.

As used herein with reference to the G
20 substituent, the numbering shall be as follows:

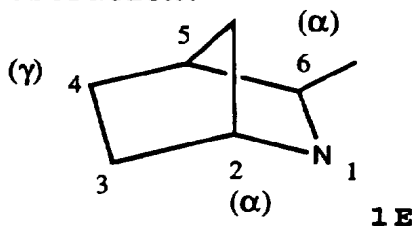


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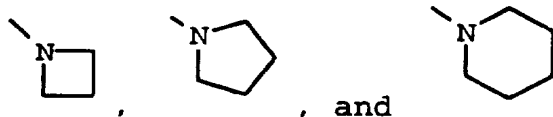
As used herein the term α shall refer to a position on the G substituent which is one position away from the N atom of the G substituent. For example, in the
25 following illustration (1E), both positions 2 and 6 are considered α . The term γ shall refer to the position on the G substituent which is opposite the N atom. For example, in the illustration (1E), position 4 is

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considered γ . Likewise, β shall refer to the 3 and 5 position in the illustration.



As used herein with reference to the G substituent, the phrase "R⁶ and R⁷ together with the nitrogen atom optionally form a 4- to 6-member ring" means that R⁶ and R⁷ are each independently hydrogen, C₁-C₆ alkyl; the R⁶ and R⁷ groups may optionally join to form a 4- to 6-member ring including the nitrogen. For example, optionally joined groups include, but not limited to:



As used herein the phrase "interacting with a muscarinic cholinergic receptor" shall include compounds which block muscarinic cholinergic receptors or modulate such receptors. Likewise, the term "interacting with a nicotinic cholinergic receptor" shall include compounds which block or modulate the receptor. The phrase shall include the effect observed when compounds act as agonists, partial agonists and/or antagonists at a cholinergic receptor.

As used herein, the term "alkoxide metal" means a metal suitable for alkoxide formation. Such alkoxide metals include, but are not limited to, Li⁺, K⁺, Na⁺, Cs⁺, and Ca⁺⁺. Especially preferred alkoxide metals include Li⁺, K⁺, and Na⁺.

As used herein, the term "halogen" means Cl, Br, F, and I. Especially preferred halogens include Cl, Br, and I.

The terms "C₁-C_n alkyl" wherein n can be from 2 through 15, as used herein, represent a branched or linear

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alkyl group having from one to the specified number of carbon atoms. Typical C₁-C₆ alkyl groups include methyl, ethyl, n-propyl, iso-propyl, butyl, iso-butyl, sec-butyl, tert-butyl, pentyl, hexyl and the like.

5 The terms "C₂-C_{n'} alkenyl" wherein n' can be from 3 through 10, as used herein, represents an olefinically unsaturated branched or linear group having from 2 to the specified number of carbon atoms and at least one double bond. Examples of such groups include, but are not limited to, 1-propenyl, 2-propenyl (-CH₂-CH=CH₂), 1,3-butadienyl, 10 (-CH=CHCH=CH₂), 1-butenyl (-CH=CHCH₂CH₃), hexenyl, pentenyl, and the like.

 The term "C₂-C₅ alkynyl" refers to an unsaturated branched or linear group having from 2 to 5 carbon atoms and at least one triple bond. Examples of such groups include, 15 but are not limited to, 1-propynyl, 2-propynyl, 1-butyne, 2-butyne, 1-pentyne, and the like.

 The terms "halogen(C₁-C₆)alkyl" and "halogen(C₂-C₆)alkenyl" refer to alkyl or alkenyl substituents having one or more independently selected halogen atoms attached at one or more available carbon atoms. These terms include, but are not limited to, chloromethyl, 1-bromoethyl, 2-bromoethyl, 1,1,1-trifluoroethyl, 1,1,2-trifluoroethyl, 1,2,2-trifluoroethyl, 2,2,2-trifluoroethyl, trifluoromethyl, 20 trifluoroethenyl, 3-bromopropyl, 3-bromo-1-propenyl, 2-bromopropyl, 2-bromo-1-propenyl, 3-chlorobutyl, 3-chloro-2-butenyl, 2,3-dichlorobutyl, 1-chloroethenyl, 2-chloroethenyl, 5-fluoro-3-pentenyl, 3-chloro-2-bromo-5-hexenyl, 3-chloro-2-bromobutyl, trichloromethyl, 1,1-dichloroethyl, 1,2-dichloroethyl, 2,2-dichloroethyl, 1,4-dichlorobutyl, 3-bromopentyl, 1,3-dichlorobutyl, 1,1-dichloropropyl, and the like. 30

 The term "C₂-C₁₀ alkanoyl" represents a group of the formula C(O)(C₁-C₉) alkyl. Typical C₂-C₁₀ alkanoyl groups include acetyl, propanoyl, butanoyl, and the like. 35

 The term "(C₁-C₆ alkyl) amino" refers to a monoalkylamino group. Examples of such groups are

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methylamino, ethylamino, *iso*-propylamino, *n*-propylamino, (*n*-propyl)amino, (*iso*-propyl)amino, *n*-propylamino, *t*-butylamino, and the like.

5 The term " C_3 - C_n cycloalkyl" wherein $n=4-8$, represents cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, and cyclooctyl.

10 The term "substituted(C_5 - C_n) cycloalkyl" refers to a cycloalkyl group as described *supra* wherein the cycloalkyl group may be substituted with from one to four substituents independently selected from the group consisting of hydrogen, C_1 - C_6 alkyl, NO_2 , halogen, halogen(C_1 - C_6)alkyl, halogen(C_2 - C_6)alkenyl, C_2 - C_6 alkenyl, CO_2R^{20} , (C_1 - C_6 alkyl) amino, $-SR^{20}$, and OR^{20} ; wherein R^{20} is selected from the group consisting of C_1 -15-alkyl, C_2 -15-alkenyl, and C_2 -15-alkynyl.

15 The term " C_3 - C_8 cycloalkyl- $(C_1$ - $C_3)$ alkyl" represents an alkyl group substituted at a terminal carbon with a C_3 - C_8 cycloalkyl group. Typical cycloalkylalkyl groups include cyclohexylethyl, cyclohexylmethyl, 3-cyclopentylpropyl, and the like.

20 The term " C_5 - C_8 cycloalkenyl" represents an olefinically unsaturated ring having five to eight carbon atoms. Such groups include, but are not limited to, cyclohexyl-1,3-dienyl, cyclohexenyl, cyclopentenyl, cycloheptenyl, cyclooctenyl, cyclohexyl-1,4-dienyl, 25 cycloheptyl-1,4-dienyl, cyclooctyl-1,3,5-trienyl and the like.

30 The term "substituted (C_5 - C_8) cycloalkenyl" refers to a cycloalkenyl group as described *supra*. wherein the cycloalkenyl group may be substituted with from one to four substituents independently selected from the group consisting of hydrogen, C_1 - C_6 alkyl, NO_2 , halogen, halogen(C_1 - C_6)alkyl, halogen(C_2 - C_6)alkenyl, C_2 - C_6 alkenyl, COR^{20} , C_2 - C_{10} alkanoyl, C_7 - C_{16} arylalkyl, CO_2R^{20} , (C_1 - C_6 alkyl) amino, $-SR^{20}$, and 35 $-OR^{20}$. Wherein R^{20} is selected from the group consisting of C_1 -15-alkyl, C_2 -15-alkenyl, C_2 -15-alkynyl.

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The term "C₅-C₈ cycloalkenyl-(C₁-C₃)alkyl" represents a C₁-C₃ alkyl group substituted at a terminal carbon with a C₅-C₈ cycloalkenyl group.

As used herein, the phrase "5 or 6 membered heterocyclic group" means a group containing from one to four N, O or S atom(s) or a combination thereof, which heterocyclic group is optionally substituted at carbon or nitrogen atom(s) with C₁-6-alkyl, -CF₃, phenyl, benzyl or thienyl, or a carbon atom in the heterocyclic group together with an oxygen atom form a carbonyl group, or which heterocyclic group is optionally fused with a phenyl group. The phrase "5 or 6 membered heterocyclic group" includes, but is not limited to, 5-membered heterocycles having one hetero atom (e.g. thiophenes, pyrroles, furans); 5-membered heterocycles having two heteroatoms in 1,2 or 1,3 positions (e.g. oxazoles, pyrazoles, imidazoles, thiazoles, purines); 5-membered heterocycles having three heteroatoms (e.g. triazoles, thiadiazoles); 5-membered heterocycles having 3-heteroatoms; 6-membered heterocycles with one heteroatom (e.g. pyridine, quinoline, isoquinoline, phenanthrine, 5,6-cycloheptenopyridine); 6-membered heterocycles with two heteroatoms (e.g. pyridazines, cinnolines, phthalazines, pyrazines, pyrimidines, quinazolines); 6-membered heterocycles with three heteroatoms (e.g. 1,3,5-triazine); and 6-member heterocycles with four heteroatoms. Particularly preferred are thiophenes, pyridines, and furans.

The term "heteroaryl" refers to a group which is a 5 or 6 membered heterocycle containing one to four N, O, or S atoms or a combination thereof.

As used herein the term "carboxy" refers to a substituent having the common meaning understood by the skilled artisan, wherein the point of attachment may be through the carbon or oxygen atom of the group.

As used herein the term "aryl" means an organic radical derived from an aromatic hydrocarbon by the removal

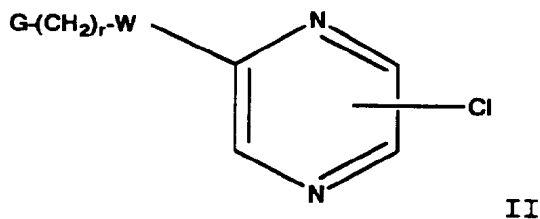
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of one atom; e.g., phenyl or naphthyl. Most preferably, aryl refers to C₆-C₁₀ aryl, wherein the aryl ring system, including any alkyl substitutions, comprises from 6 to 10 carbon atoms; e.g., phenyl, 3,3-dimethylphenyl, naphthyl, and the like. The aryl radical may be substituted by one or two C₁-C₆ straight or branched alkyl. The term "aryl(C₁-C₃)alkyl" refers to any aryl group which is attached to the parent moiety via the alkyl group.

As used herein the term "malfunctioning of the muscarinic cholinergic system" shall have the meaning accepted by the skilled artisan. Likewise, the term "malfunctioning of the nicotinic cholinergic system" shall have the art recognized meaning. For example the term shall refer to, but is not in any way limited to, conditions such as glaucoma, psychosis, schizophrenia or schizophreniform conditions, depression, sleeping disorders, epilepsy, and gastrointestinal motility disorders. Other such conditions include Alzheimer's Disease and incontinence.

Compounds of this invention can be prepared by

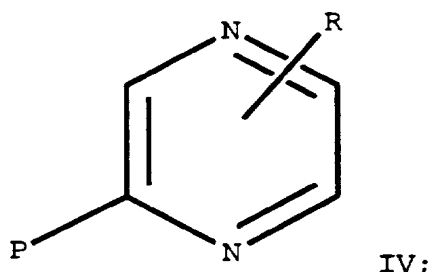
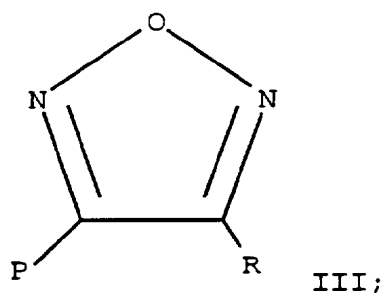
a) reacting a compound of formula II



wherein G, W and r have the meaning defined above with h⁺QR wherein h⁺ is an alkali metal; Q is O or S and R has the meaning defined above, or

b) reacting a compound of formula III or IV

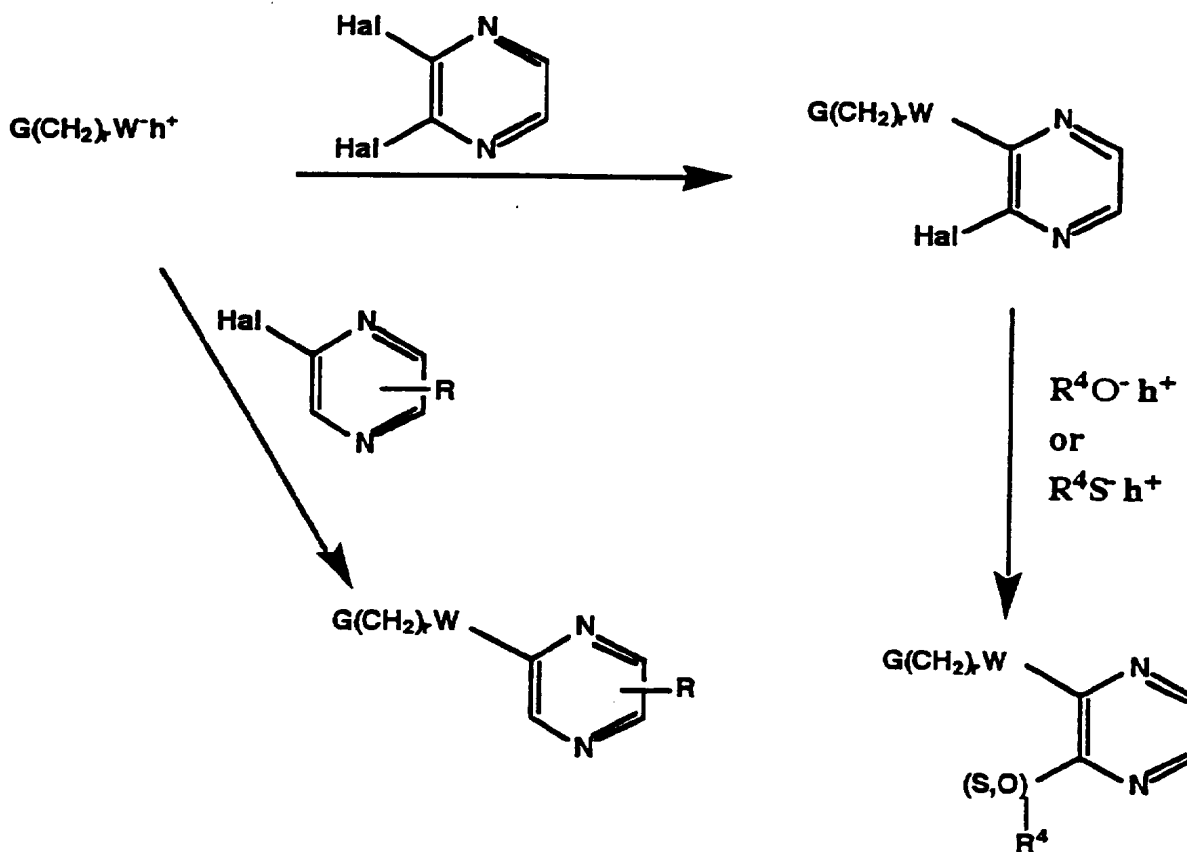
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wherein P is R^9SO_2 or halogen; R^9 is C_{1-8} straight or branched
chain alkyl or aryl; and R has the meaning defined above;
with $G-(CH_2)_r-W-h^+$ wherein h^+ , G, W and r have the meanings
defined above.

The compounds of this invention can be prepared
as described *supra*. and by using the chemical processes
illustrated in Scheme I. The starting materials for the
illustrated process are commercially available or may be
prepared using methods known to the skilled artisan.

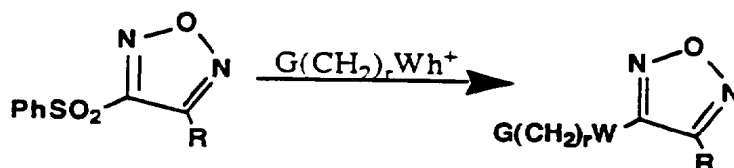
Scheme I



As used in Scheme I, R, h^+ , and G are as defined *supra*. As used in Scheme I, the term "Hal" refers to Cl, Br, I, and R^9SO_2 .

Compounds of this invention may be prepared by the process illustrated in Scheme II

Scheme II



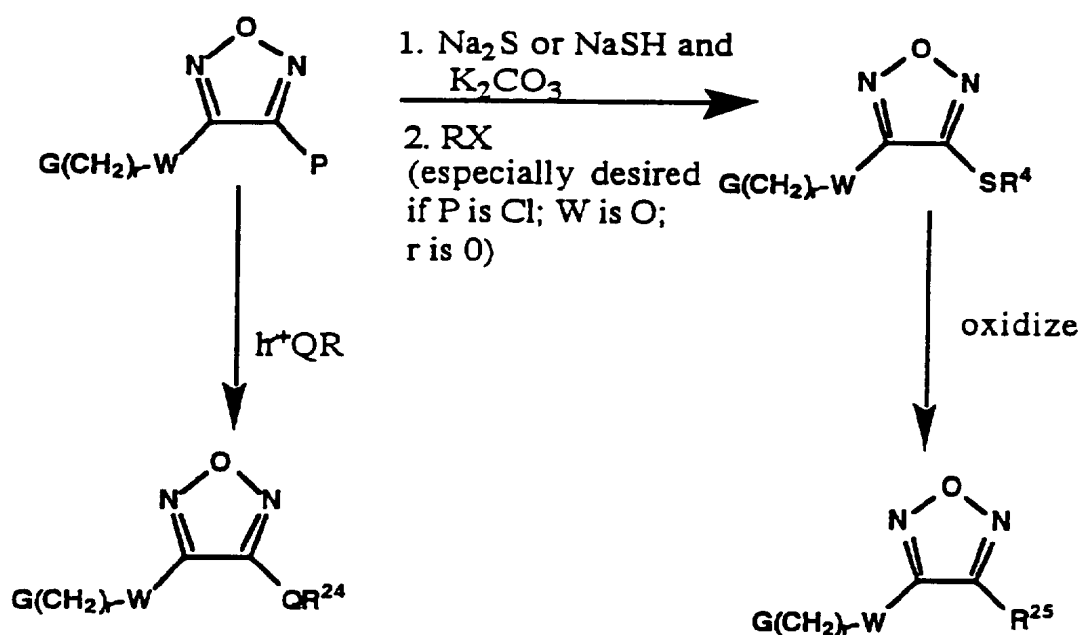
The artisan will recognize that the starting materials for the process of Scheme II are commercially

available or can be prepared using methods familiar to the skilled artisan.

Compounds of Formula I wherein R is an R^4 group, can be prepared using methods well known in the art. See
5 for example, U.S. Patent Number 5,043,345.

Further, compounds of Formula I may be prepared using the process illustrated in the following Scheme III

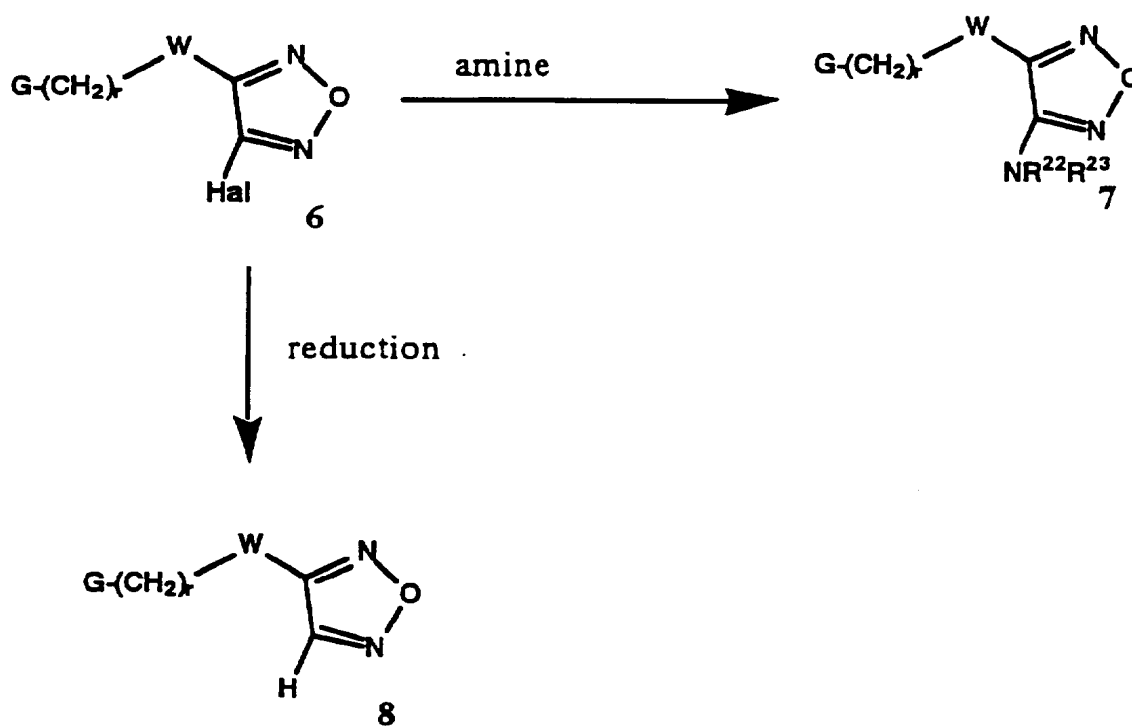
Scheme III



10 As used in Scheme III, Q may be N, O or S; R^{24} is selected from the group consisting of hydrogen, R^4 , R^5 , R^6 , and R^7 ; R^{25} is selected from the group consisting of SOR^4 and SO_2R^4 ; all other meanings are as defined *supra*.

15 Additional compounds of Formula I may be prepared using the process illustrated by Scheme IV.

Scheme IV

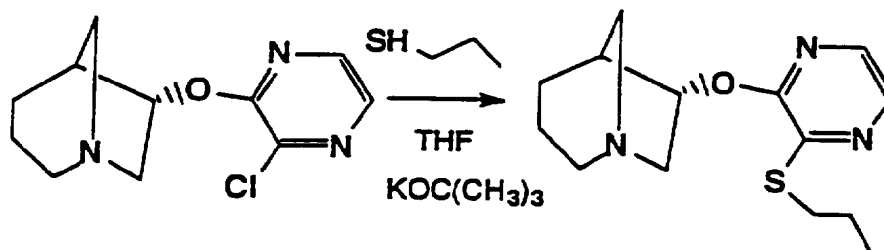


As used in Scheme IV, Hal, W, r, and G are as defined *supra*. As used in Scheme IV, R^{22} and R^{23} are independently selected from the group consisting of hydrogen, R^6 and R^7 .

When the G substituent contains a secondary nitrogen protected by a protecting group, the protecting group may be removed using standard methods known to the skilled artisan. An especially preferred protecting group is carbamate. One particularly useful reference concerning protecting groups is Greene, Protecting Groups in Organic Synthesis, (John Wiley & Sons, New York, 1981).

Certain compounds of this invention may more preferably be prepared using the process of Scheme V.

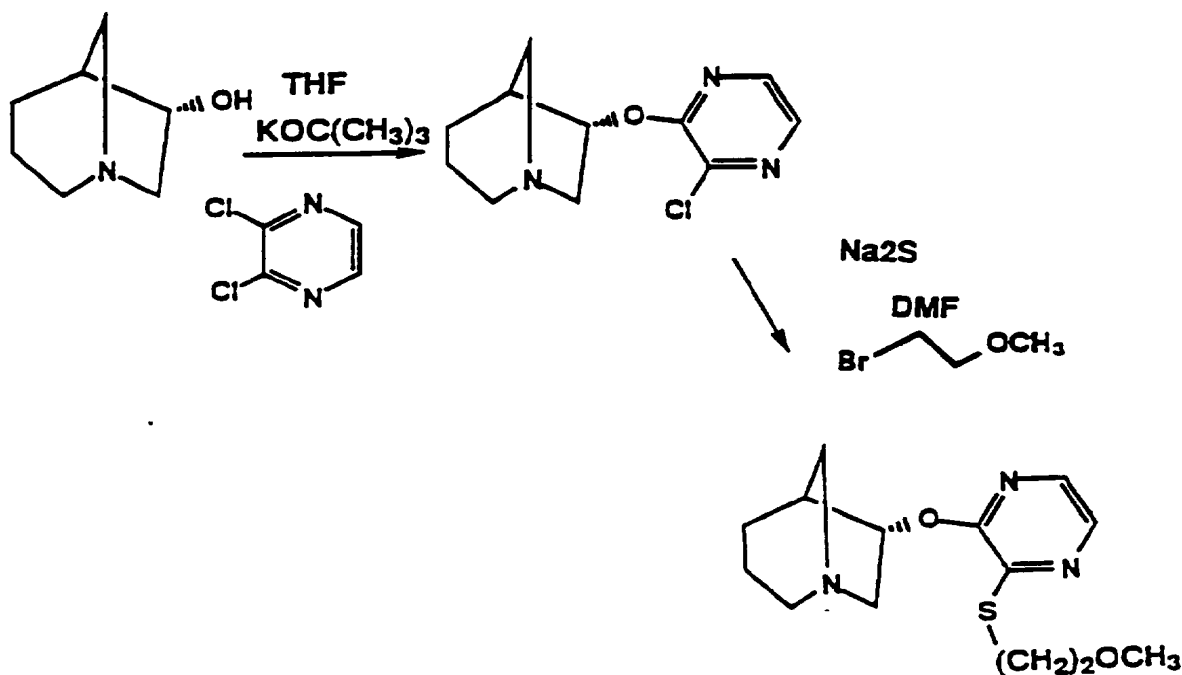
Scheme V



- 5 Potassium t-butoxide or another appropriate alkali metal base was added at about 0° C. to an alkylthiol in THF and stirred. The haloopyrazine was added and the reaction stirred at about room temperature. A sample of about 1 N acid was added and the aqueous solution washed. The pH was adjusted to about
- 10 12.0. The product was extracted, dried and evaporated. The salt was optionally formed using standard methods.

15 Certain of the compounds of this invention can more preferably be prepared using the process illustrated by Scheme VI.

Scheme VI



The alcohol was added to a mixture of potassium t-butoxide in THF at about room temperature. The reaction was cooled to about 5° C. The 2,3-dichloropyrazine in THF was added to the mixture. The reaction mixture was stirred at about room temperature for about 2 hrs, condensed, diluted with water and ethyl acetate. The organic solution was dried and condensed. The chloropyrazine derivative and sodium sulfide ($\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$), were heated in DMF at about 50° C. for about 3.5 hr, cooled to about 0° C. Then 2-Bromoethylmethyl-ether was added. The reaction was stirred at about room temperature overnight and diluted with ethyl acetate and about 5 N acid. The aqueous layer was washed and the pH adjusted to about 12.0. The product was extracted, dried, condensed and purified by HPLC. The salt form of the product was optionally formed using standard methods.

The pharmacological properties of the compounds of the invention can be illustrated by determining their capability to inhibit the specific binding of ^3H -Oxotremorine-M (^3H -Oxo). Birdsall N.J.M., Hulme E.C., and Burgen A.S.V. (1980). "The Character of Muscarinic Receptors in Different Regions of the Rat Brain". Proc. Roy. Soc. London (Series B) 207,1.

^3H -Oxo labels muscarinic receptor in the CNS (with a preference for agonist domains of the receptors). Three different sites are labeled by ^3H -Oxo. These sites have affinity of 1.8, 20 and 3000 nM, respectively. Using the present experimental conditions only the high and medium affinity sites are determined.

The inhibitory effects of compounds on ^3H -oxo binding reflects the affinity for muscarinic acetylcholine receptors.

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All preparations are performed at 0-4°C unless otherwise indicated. Fresh cortex (0.1-1 g) from male

Wistar rats (150-250 g) is homogenized for 5-10 s in 10 mL 20 mM Hepes pH: 7.4, with an Ultra-Turrax homogenizer. The homogenizer is rinsed with 10 mL of buffer and the combined suspension centrifuged for 15 min. at 40,000 x g. The
5 pellet is washed three times with buffer. In each step the pellet is homogenized as before in 2 x 10 mL of buffer and centrifuged for 10 min. at 40,000 x g.

The final pellet is homogenized in 20 mM Hepes
10 pH: 7.4 (100 mL per g of original tissue) and used for binding assay. Aliquots of 0.5 mL is added 25 μ L of test solution and 25 μ L of ^3H -Oxotremorine (1.0 nM, final concentration) mixed and incubated for 30 min. at 25°C. Non-specific binding is determined in triplicate using
15 arecoline (1 μ g/mL, final concentration) as the test substance. After incubation samples are added 5 mL of ice-cold buffer and poured directly onto Whatman GF/C glass fiber filters under suction and immediately washed 2 times with 5 mL of ice-cold buffer. The amount of radioactivity
20 on the filters are determined by conventional liquid scintillation counting. Specific binding is total binding minus non specific binding.

Test substances are dissolved in 10 mL water (if
25 necessary heated on a steam-bath for less than 5 min.) at a concentration of 2.2 mg/mL. 25-75% inhibition of specific binding must be obtained before calculation of IC_{50} . The test value will be given as IC_{50} (the concentration (nM) of the test substance which inhibits the specific binding of
30 ^3H -oxo by 50%).

IC_{50} = (applied test substance concentration) x $(C_x / C_o - C_x)$ nM
where C_o is specific binding in control assays and C_x is the specific binding in the test assay. (The calculations assume normal mass-action kinetics).

35

Furthermore the pharmacological properties of the compounds of the invention can also be illustrated by

determining their capability to inhibit $^3\text{HPRZ}$ (pirenzepine, [N-methyl- ^3H]) binding to rat cerebral cortex membranes.

Pirenzepine binds selectively to subtype of muscarinic receptors. Historically the type is named the M_1 -site, whereas pirenzepine sensitive site would be more appropriate. Although selective for M_1 -sites pirenzepine also interact with M_2 -sites.

All preparations are performed at 0-4°C unless otherwise indicated. Fresh cortex (0.1-1 g) from male Wistar rats (150-200 g) is homogenized for 5-10 s in 10 mL 20 mM Hepes pH: 7.4, with an Ultra-Turrax homogenizer. The homogenizer is rinsed with 2 x 10 mL of buffer and the combined suspension centrifuged for 15 min. at 40,000 x g. The pellet is washed three times with buffer. In each step the pellet is homogenized as before in 3 x 10 mL of buffer and centrifuged for 10 min. at 40,000 x g.

The final pellet is homogenized in 20 mM Hepes pH: 7.4 (100 mL per g of original tissue) and used for binding assay. Aliquots of 0.5 mL is added 20 μL of test solution and 25 μL of $^3\text{HPRZ}$ (1.0 nM, final conc.), mixed and incubated for 60 min. at 20°C. Non-specific binding is determined in triplicate using atropine (1.0 $\mu\text{g/mL}$, final conc.) as the test substance. After incubation samples are added 5 mL of ice-cold buffer and poured directly onto Whatman GF/C glass fiber filters under suction and immediately washed 2 times with 5 mL of ice-cold buffer. The amount of radioactivity on the filters are determined by conventional liquid scintillation counting. Specific binding is total binding minus non-specific binding.

Test substances are dissolved in 10 mL water, at a concentration of 0.22 mg/mL. 25-75% inhibition of specific binding must be obtained before calculation of IC_{50} .

The test value will be given as IC_{50} (the concentration (nM) of the test substance which inhibits the specific binding of 3HPRZ by 50%).

5 $IC_{50} = (\text{applied test substance concentration}) \times (C_x / C_o - C_x) nM$
where C_o is specific binding in control assays and C_x is the specific binding in the test assay. (The calculations assume normal mass-action kinetics).

10 Test results obtained by testing some compounds of the present invention will appear from the following table 1.

15

TABLE 1

	Compound	$^3H\text{-Oxo-M}$	3HPRZ
		IC_{50}, nM	IC_{50}, nM
20	1	81	56
	2	374	253
	3	19.3	14.5
	6	2.5	0.9
	4	25	21
25	5	40	32
	7	16	6.7
	8	1040	>1000
	9	36	30

20

	Compound No.	Oxo-M IC-50, nM	Pir IC-50, nM
5	10	354	223
	11	56	53
	12	25	13
	13	74	42
	14	26	21
10	15	14	13
	16	39	23
	17	17	4.5
	18	21	5.4
	19	121	108
15	20	245	246
	21	26	123
	22	140	52
	23	4.9	2.7
	24	2.2	0.54
20	25	180	680
	26	>1000	>1000
	27	>1000	>1000
	28	>10,000	5710
	29	1.7	0.68
25	30	4.4	0.82
	41	3.2	1.6
	42	9.1	4.8
	43	8.1	2.2
	31	3.4	1.7
30	32	3.9	4.0
	33	1.5	0.7
	34	2.0	0.66
	35	3.2	0.54
	36	0.34	5.8
35	37	1.3	0.76
	38	6.2	3.3
	39	10	80
	40	60	17

Nicotinic Channel Receptor Binding Protocol:

The activity of the compounds claimed herein at the nicotinic receptor can be accomplished by the following assay.

5 Binding of [³H]-cystine to nicotinic receptors was accomplished using crude synaptic membrane preparations from whole rat brain (Pabreza et al. *Molecular Pharmacol.*, 1990, 39:9). Washed membranes were stored at about -80 °C prior to use. Frozen aliquots were slowly thawed and resuspended in
10 20 volumes of buffer (containing: 120 mM NaCl, 5 mM KCl, 2 mM MgCl₂, 2 mM Tris-Cl, pH 7.4 @4°C). After centrifuging at 20,000x g for 15 minutes, the pellets were resuspended in about 30 volumes of buffer. Homogenate (containing about 125-150ug protein) was added to tubes containing
15 concentrations of test compound and [³H-cystine] (1.25 nM) in a final volume of 500 uL. Samples were incubated for about 60 minutes at about 4°C, then rapidly filtered through GF/B filters presoaked in 0.5% polyethylimine using 3 x 4 mL of ice cold buffer. The filters were counted.

20

Nicotinic Binding Data

	Compound No.	Cystine
		K _i , nM
25	26	130
	19	2780
	17	21400
	21	130
30	18	580
	22	210
	27	110
	6	5490

35 Some examples of compounds contemplated by this invention include, but are not limited to: (+/-)-3-butylthio-4-(azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole, (+/-)-3-

(2-butyloxy)-4-[(+/-)-3-azabicyclo[2.2.2]octyloxy)-1,2,5-oxadiazole, (+/-)-3-butyloxy-4-[endo-(+/-)-6-[1-azabicyclo[3.2.1]octyloxy)]-1,2,5-oxadiazole, 2-[exo-(+/-)-3-[1-azabicyclo[3.2.1]octyloxy)]pyrazine, 3-(2,2,3,3,4,4,4-heptafluorobutyloxy)-4-[(+/-)-3-(1-azabicyclo[2.2.2]octyloxy)]-1,2,5-oxadiazole, 3-methoxy-4-(1-azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole, 3-pentylthio-4-(1-azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole, trans-3-butyloxy-4-(2-dimethylaminocyclopentyl)-1,2,5-oxadiazole, 3-butylthio-4-(3-azetidinyloxy)-1,2,5-oxadiazole, 3-(3-N-(2-thiazolidonyl)propylthio)-4-(1-azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole, 3-chloro-4-(1-azabicyclo[3.2.1]octyl-6-oxy)-1,2,5-oxadiazole, 3-(2,2-thio-5-trifluoromethylthienyl)ethylthio)-4-azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole, 3-butylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)]pyrazine, 3-butyloxy-2-[3-endo-(1-azabicyclo[2.2.1]heptyloxy)]pyrazine, 3-butylthio-4-[3-endo-(1-azabicyclo[2.2.1]heptyloxy)]-1,2,5-oxadiazole, 3-(2-butyloxy)-2-[6-endo-(1-azabicyclo[3.2.1]octyloxy)]pyrazine, 3-hexylthio-2-[6-endo-(2-azabicyclo[2.2.1]heptyloxy)]pyrazine, 3-hexyloxy-4-[6-endo-(2-azabicyclo[2.2.2]octyloxy)]-1,2,5-oxadiazole, 3-(3-phenylpropynylthio)-2-[2-endo-(7-azabicyclo[2.2.1]heptyloxy)]pyrazine, 3-(4,4,4-trifluorobutylthio)-4-[2-endo-(7-azabicyclo[2.2.1]heptyloxy)]-1,2,5-oxadiazole, 3-(2-phenoxyethylthio)-4-[3-endo-(1-azabicyclo[3.2.1]octyloxy)]-1,2,5-oxadiazole, 3-(2-methylthioethoxy)-2-[3-endo-(1-azabicyclo[3.2.1]octyloxy)]pyrazine, 3-propargyl-2-[4-(1-azabicyclo[2.2.1]heptyloxy)]pyrazine, 3-(5-hexenyloxy)-4-[7-endo-(2-azabicyclo[2.2.1]heptyloxy)]-1,2,5-oxadiazole, 3-butyl-4-[5-(1-azabicyclo[3.2.1]octyloxy)]-1,2,5-oxadiazole, 3-cyclopropylmethylthio-2-[2-endo-(8-azabicyclo[3.2.1]octyloxy)]pyrazine, and 3-cyclobutylmethyl-4-[2-endo-(8-azabicyclo[3.2.1]octyloxy)]-1,2,5-oxadiazole.

The compounds of the invention are effective over a wide dosage range. For example, in the treatment of

adult humans, dosages from about 0.05 to about 100 mg, preferably from about 0.1 to about 100 mg, per day may be used. A most preferable dosage is about 0.1 mg to about 70 mg per day. In choosing a regimen for patients suffering from diseases in the central nervous system caused by malfunctioning of the muscarinic cholinergic system it may frequently be necessary to begin with a dosage of from about 20 to about 70 mg per day and when the condition is under control to reduce the dosage as low as from about 0.1 to about 10 mg per day. The exact dosage will depend upon the mode of administration, form in which administered, the subject to be treated, the body weight of the subject to be treated, and the preference and experience of the physician or prescribing caregiver in charge.

The route of administration may be any route, which effectively transports the active compound to the appropriate or desired site of action, such as oral or parenteral e.g. rectal, transdermal, depot, subcutaneous, intravenous, intramuscular or intranasal, the oral route being preferred.

Typical compositions include a compound of formula I or a pharmaceutically acceptable acid addition salt thereof, associated with a pharmaceutically acceptable excipient which may be a carrier, or a diluent or be diluted by a carrier, or enclosed within a carrier which can be in the form of a capsule, sachet, paper, or other container. In making the compositions, conventional techniques for the preparation of pharmaceutical compositions may be used. For example, the active compound will usually be mixed with a carrier, or diluted by a carrier, or enclosed within a carrier which may be in the form of a ampoule, capsule, sachet, paper, or other container. When the carrier serves as a diluent, it may be solid, semi-solid, or liquid material which acts as a vehicle, excipient, or medium for the active compound. The

active compound can be adsorbed on a granular solid container for example in a sachet. Some examples of suitable carriers are water, salt solutions, alcohols, polyethylene glycols, polyhydroxyethoxylated castor oil, gelatine, lactose, amylose, magnesium stearate, talc, silicic acid, fatty acid monoglycerides and diglycerides, pentaerythritol fatty acid esters, hydroxymethylcellulose and polyvinylpyrrolidone. The formulations may also include wetting agents, emulsifying and suspending agents, preserving agents, sweetening agents, or flavoring agents. The formulations of the invention may be formulated so as to provide quick, sustained, or delayed release of the active ingredient after administration to the patient by employing procedures well known in the art.

The pharmaceutical preparations can be sterilized and mixed, if desired, with auxiliary agents, emulsifiers, salt for influencing osmotic pressure, buffers and/or coloring substances and the like, which do not deleteriously react with the active compounds.

For parenteral application, particularly suitable are injectable solutions or suspensions, preferably aqueous solutions with the active compound dissolved in polyhydroxylated castor oil.

Tablets, dragees, or capsules having talc and/or a carbohydrate carrier or binder or the like are particularly suitable for oral application. Preferable carriers for tablets, dragees, or capsules include lactose, corn starch, and/or potato starch. A syrup or elixir can be used in cases where a sweetened vehicle can be employed.

Generally, the compounds are dispensed in unit form comprising from about 0.1 to about 100 mg in a pharmaceutically acceptable carrier per unit dosage.

In order to more fully illustrate the operation of this invention, the following formulation examples are provided. The examples are illustrative only, and are not intended to limit the scope of the invention in any way.

5

Formulation 1

A typical tablet, appropriate for use in this method, may be prepared using conventional techniques and may contain:

10

	Amount per Tablet	Concentration by Weight (%)
(+)-Endo-3-butylthio-		
15 2-(1-azabicyclo[3.2.1]-		
octyl-6-oxy)-1,2,5-		
oxadiazole	5.0 mg	4.7
Lactosum	67.8 mg Ph. Eur.	64.2
Avicel®	31.4 mg	29.8
20 Amberlite®	1.0 mg	1.0
magnesium stearate	<u>0.25 mg Ph. Eur.</u>	<u>0.3</u>
	105.45 mg	100

25

Formulation 2

Hard gelatin capsules are prepared using the following ingredients:

	Amount per Tablet	Concentration by Weight (%)
(+)-Exo-3-butyloxy-2-		
(N-methyl-8-azabicyclo-		
30 [3.2.1]octyl-3-oxy)-		
pyrazine	0.1 mg	0.05
35 starch dried	200 mg	95.2
magnesium stearate	<u>10 mg</u>	<u>4.8</u>
	210.1 mg	100

The above ingredients are mixed and filled into hard gelatin capsules in 210.1 mg quantities.

Formulation 3

5 Suspensions each containing 1 mg of medicament per 5 mL dose are as follows:

	Amount per 5mL of <u>suspension</u>
(±)-3-(3-phenylethylthio)-	
10 4-(1-azabicyclo[2.2.2]octyl-	
3-oxy)-1,2,5-oxadiazole	1 mg
sodium carboxymethyl cellulose	50 mg
15 syrup	1.25 mL
benzoic acid solution	0.10 mL
flavor	q.v.
20 color	q.v.
water	q.s. to 5 mL

25 The medicament is passed through a No. 45 mesh U.S. sieve and mixed with the sodium carboxymethyl cellulose and syrup to form a smooth paste. The benzoic acid solution, flavor and color is diluted with some of the water and added to the paste with stirring. Sufficient

30 water is then added to produce the required volume.

 The compounds of this invention may be suitable for administration to an animal. Such animals include both domestic animals, for example livestock, laboratory animals, and household pets, and non-domestic animals such

35 as wildlife. More preferred, the animal is a vertebrate. Most preferred, a compound of this invention shall be administered to a mammal. It is especially preferred that

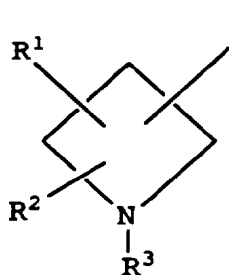
the animal is a domestic mammal or a human. The most preferred mammal is a human. For such purposes, a compound of this invention may be administered as a feed additive or in bulk form.

5 The intermediates and processes of the present invention are useful for preparing compounds having beneficial muscarinic receptor activity. The compounds of the present invention have such useful muscarinic receptor activity. Certain compounds and conditions within the scope
10 of this invention are preferred. The following conditions, invention embodiments, and compound characteristics listed in tabular form may be independently combined to produce a variety of preferred compounds and process conditions. The following list of embodiments of this invention is not
15 intended to limit the scope of this invention in any way.

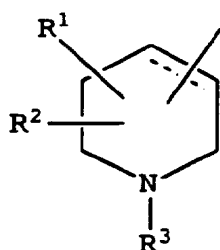
Some preferred characteristics of compounds of formula I are:

- A) W is S;
- 20 B) r is 1 or 2;
- C) G is selected from **het-1** and **het-5**;
- D) G is unsaturated;
- E) G is **het-4**;
- F) G is an azabicyclic having 7 ring carbon atoms
25 and a nitrogen atom;
- G) G is **het-6**;
- H) r is 0;
- I) R is selected from halogen, -OR⁵Y, -SR⁵Y, -OR⁵ZY, -SR⁵ZY, -OR⁵ZR⁴, -SR⁵ZR⁴, -OR⁴, and -SR⁴;
- 30 J) W is O;
- K) m is 1;
- L) n is 1;
- M) p is 2;
- N) G is **het-3**
- 35 O) G is **het-2**
- P) a compound of Formula I
- Q) a compound of Formula I'

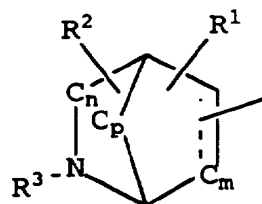
- R) a compound of Formula I
wherein W is oxygen or sulphur;
R is selected from the group consisting of hydrogen, amino,
halogen, NHR^6 , NR^6R^7 , R^4 , $-\text{OR}^4$, $-\text{SR}^4$, $-\text{SOR}^4$, $-\text{SO}_2\text{R}^4$, C_3 -10-
5 cycloalkyl, C_4 -12-(cycloalkylalkyl), $-\text{Z}-\text{C}_3$ -10-cycloalkyl and
 $-\text{Z}-\text{C}_4$ -12-(cycloalkylalkyl); R^4 is selected from the group
consisting of C_1 -15-alkyl, C_2 -15-alkenyl, and C_2 -15-
alkynyl, each of which is optionally substituted with one
or more independently selected from the group consisting of
10 halogen(s), $-\text{CF}_3$, $-\text{CN}$, Y, phenyl and phenoxy wherein phenyl
or phenoxy is optionally substituted with one or more
selected from the group consisting of halogen, $-\text{CN}$, C_1 -4-
alkyl, C_1 -4-alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or
R is phenyl or benzyloxycarbonyl, each of which is
15 optionally substituted with one or more substituents
independently selected from the group consisting of
halogen, $-\text{CN}$, C_1 -4-alkyl, C_1 -4-alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$
and $-\text{CSNH}_2$; or
R is selected from the group consisting of $-\text{OR}^5\text{Y}$, $-\text{SR}^5\text{Y}$,
20 $\text{OR}^5-\text{Z}-\text{Y}$, $-\text{SR}^5\text{ZY}$, $-\text{O}-\text{R}^5-\text{Z}-\text{R}^4$ and $-\text{S}-\text{R}^5-\text{Z}-\text{R}^4$;
Z is oxygen or sulphur;
 R^5 is selected from the group consisting of C_1 -15-alkyl,
 C_2 -15-alkenyl, and C_2 -15-alkynyl;
Y is a 5 or 6 membered heterocyclic group; and
25 G is selected from one of the following azacyclic or
azabicyclic ring systems:



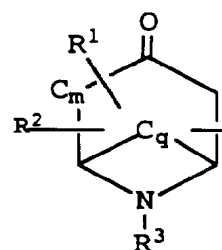
het-1



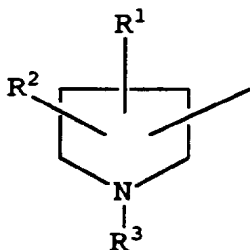
het-2



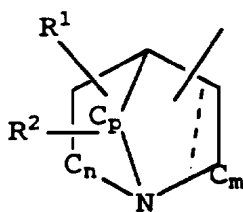
het-3



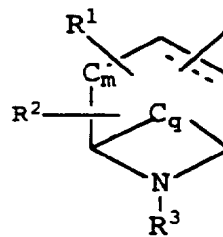
het-4



het-5



het-6



het-7

or G can optionally be substituted C₃-C₈ cycloalkyl wherein
 5 the substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are selected from the group
 consisting of hydrogen and C₁₋₆-alkyl; or R⁶ and R⁷ together
 with the nitrogen atom optionally form a 4- to 6-member
 ring;

10 R¹ and R² independently are selected from the group
 consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-
 alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a
 substituent independently selected from the group consisting
 of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl;

15 R³ is selected from the group consisting of hydrogen, C₁₋₅-
 alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and
 C₁₋₆-alkyl;

n is 0, 1 or 2;

20 m is 0, 1 or 2;

p is 0, 1 or 2;

q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond;

provided that when W is O and G is a saturated azabicyclic group having from 7 to 11 ring carbon atoms and a nitrogen atom wherein the nitrogen atom is separated from the W atom by 2 to 3 ring carbon atoms;

or a pharmaceutically acceptable salt or solvate thereof;

S) a compound of Formula I'

wherein W is oxygen or sulphur;

R is selected from the group consisting of hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-\text{OR}^4$, $-\text{SR}^4$, $-\text{SOR}^4$, $-\text{SO}_2\text{R}^4$, C_{3-10} -cycloalkyl, C_{4-12} -(cycloalkylalkyl), $-\text{Z}-\text{C}_{3-10}$ -cycloalkyl and $-\text{Z}-\text{C}_{4-12}$ -(cycloalkylalkyl); R^4 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -

alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of halogen(s), $-\text{CF}_3$, $-\text{CN}$, Y, phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, $-\text{CN}$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or

R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, $-\text{CN}$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or

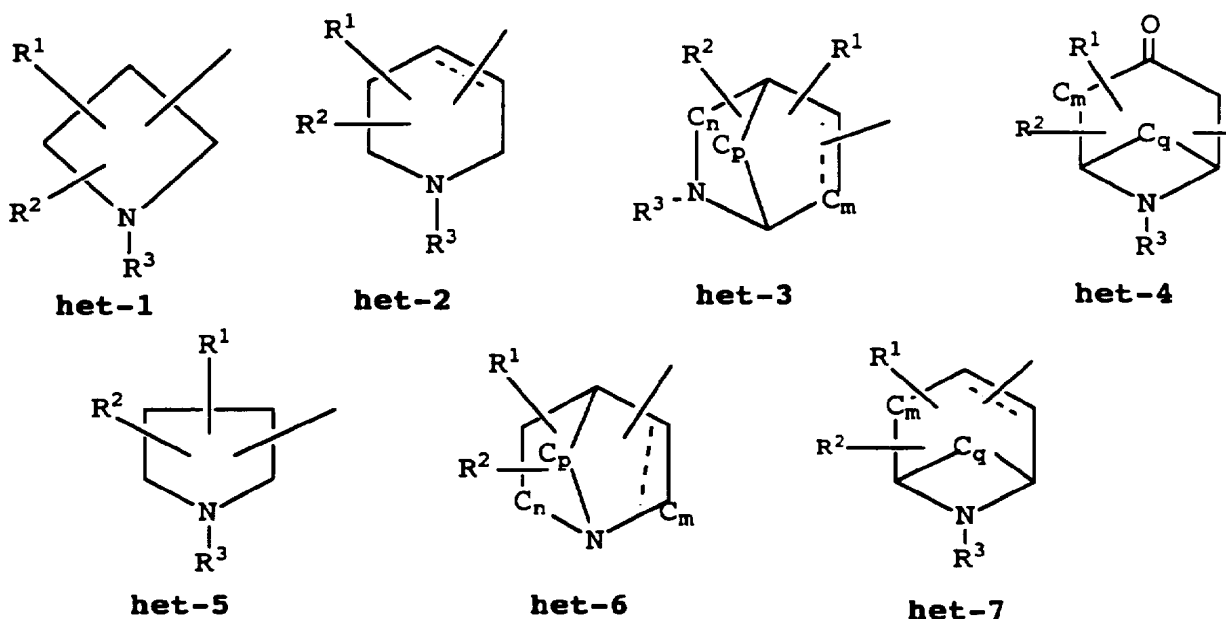
R is selected from the group consisting of $-\text{OR}^5\text{Y}$, $-\text{SR}^5\text{Y}$, $\text{OR}^5-\text{Z}-\text{Y}$, $-\text{SR}^5\text{ZY}$, $-\text{O}-\text{R}^5-\text{Z}-\text{R}^4$ and $-\text{S}-\text{R}^5-\text{Z}-\text{R}^4$;

Z is oxygen or sulphur;

R^5 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl;

Y is a 5 or 6 membered heterocyclic group; and

G is selected from one of the following azacyclic or azabicyclic ring systems:



or G can optionally be substituted C₃-C₈ cycloalkyl wherein
 5 the substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are selected from the group
 consisting of hydrogen and C₁₋₆-alkyl; or R⁶ and R⁷ together
 with the nitrogen atom optionally form a 4- to 6-member
 ring;

10 R¹ and R² independently are selected from the group
 consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-
 alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a
 substituent independently selected from the group consisting
 of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl;

15 R³ is selected from the group consisting of hydrogen, C₁₋₅-
 alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and
 C₁₋₆-alkyl;

n is 0, 1 or 2;

20 m is 0, 1 or 2;

p is 0, 1 or 2;

q is 1 or 2;

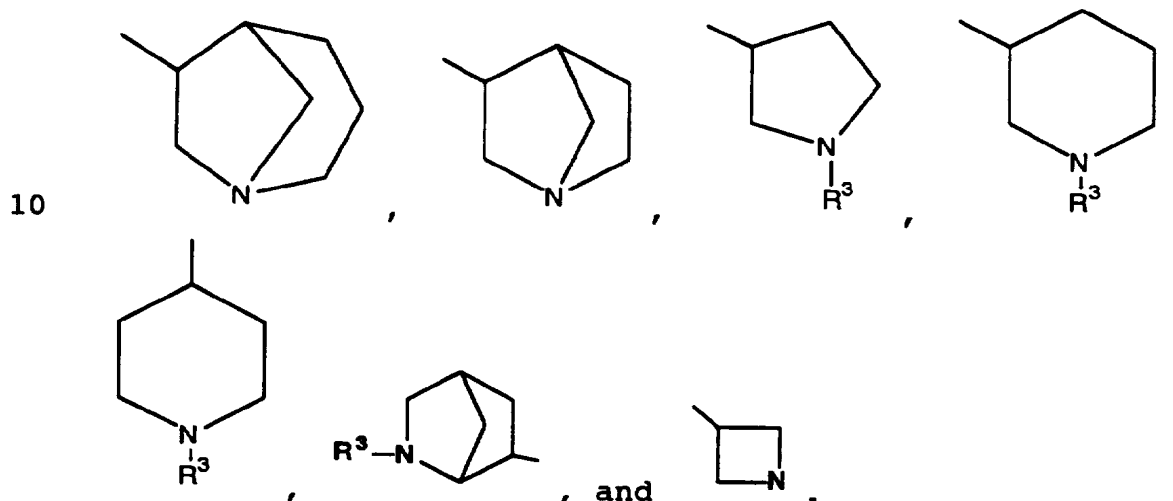
r is 0, 1 or 2;

..... is a single or double bond;

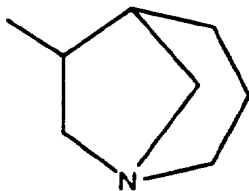
provided that when W is O and G is a saturated azabicyclic group having from 7 to 11 ring carbon atoms and a nitrogen atom wherein the nitrogen atom is separated from the W atom by 2 to 3 ring carbon atoms;

or a pharmaceutically acceptable salt or solvate thereof.

T) The G substituent is selected from the group consisting of



U) The G substituent is



15 V) R is selected from the group consisting of -SR^{4'}, SOR^{4'}, -SO₂R^{4'}, substituted benzyloxycarbonyl wherein the substituents are one or more independently selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl).

20 W) R is selected from the group consisting of R⁴, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl); and

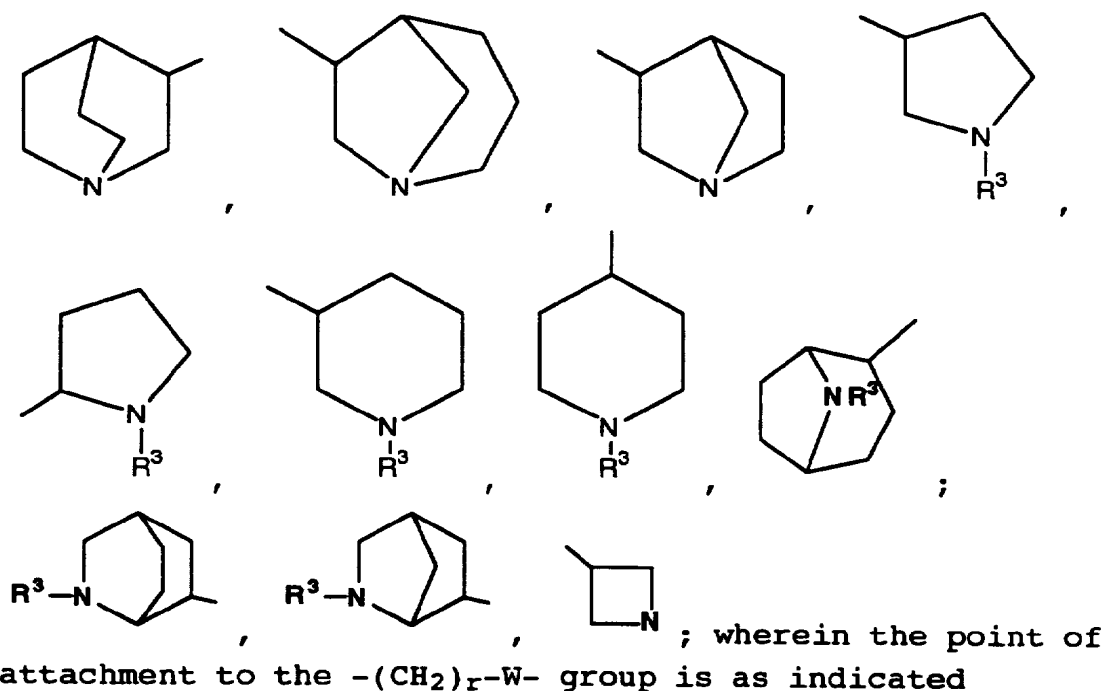
R⁴ is selected from the group consisting of substituted C₅₋₁₅-alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of
5 halogen(s), -CF₃, -CN, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂.

X) G is selected from the group consisting of
10 het-4, het-7, het-6 wherein n=2; het-3 wherein one of n and m is 0 or 2; and het-3 wherein the I or I' group is attached at the bridgehead of het-3.

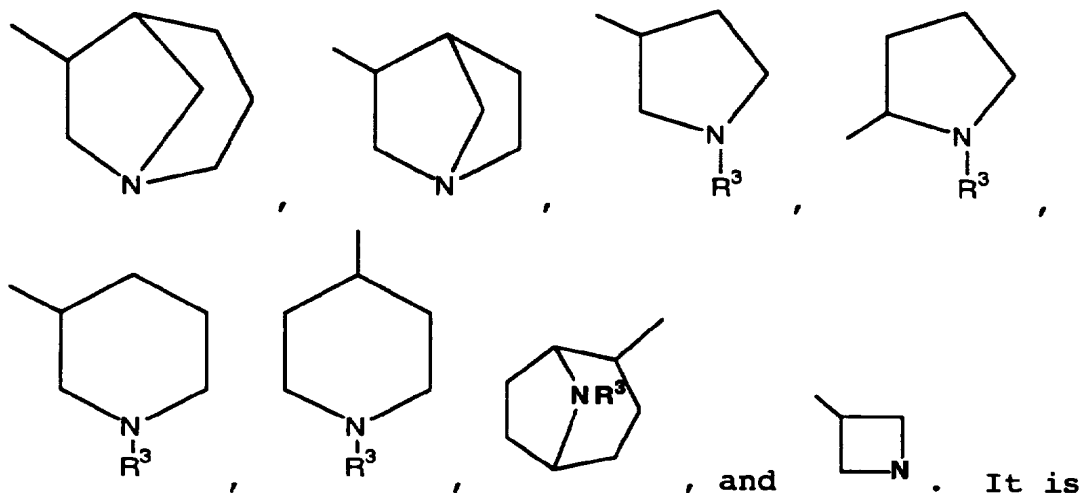
Especially preferred compounds of this invention have the characteristics of A-F,P; A-F,Q; characteristics
15 of A, G, H, M, F; characteristics of G-O,Q; or the characteristics of G-J,M,P; or G-J,M,Q. The characteristics of R and S may be particularly preferred.

Further, especially preferred R groups include phenyl, benzyloxycarbonyl, -OR⁵Y, -SR⁵Y, OR⁵-Z-Y, -SR⁵ZY,
20 -O-R⁴-Z-R⁵ or -S-R⁴-Z-R⁵, -SOR⁴, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl) wherein Z is oxygen or sulphur, R⁵ is C₁₋₁₅-alkyl, C₂₋₁₅-alkenyl, C₂₋₁₅-alkynyl, Y is a 5 or 6
membered heterocyclic group containing one to four N, O or
25 S atom(s) or a combination thereof, R₄ is C₁₋₁₅-alkyl, C₂₋₁₅-alkenyl, and C₂₋₁₅-alkynyl.

Further, especially preferred G groups include the following heterocycles:



5 Some particularly preferred G groups include



another preferred embodiment of this invention that G is not an azabicyclic, particularly when W is oxygen.

10 Additionally, another embodiment of this invention which can be preferred is that when W is O and G is alkyl, R is not halogen.

15 The invention will now be described in further detail with reference to the following examples. The examples are provided for illustrative purposes, and are

not to be construed as limiting the scope of the invention in any way.

EXAMPLE 1

5 (+/-)-3-Butyloxy-4-(1-azabicyclo[2.2.2]octyl-3-oxy)
 -1,2,5-oxadiazole

 A suspension of 3,4-diphenylsulfonyl-1,2,5-oxadiazole oxide (4.6 g, 0.126 mol, Ref. J.Chem. Soc. 1964, 904.) in 1-butanol (400 mL) was heated to 55-60°C as a solution of sodium 1-butyloxide (0.3 g Na, 40 mL 1-butanol) was added dropwise. After 1 h, the solvent was evaporated, residue was treated with H₂O, and the mixture extracted with ether (3X). 15 The extracts were washed with H₂O, dried, and the solvent evaporated to give a white solid (3.15 g). The solid was heated to reflux overnight in P(OCH₃)₃ (30 mL) then poured into ice-H₂O containing HCl (6 mL, 5N). The mixture was extracted with ether, the extracts washed with brine, dried, 20 and the solvent evaporated to give a yellow liquid. Radial chromatography (15% EtOAc/hexane) gave a clear liquid (1.85 g). The liquid was dissolved in THF (30 mL) and added dropwise to a mixture prepared from 1-azabicyclo[2.2.2]octan-3-ol (1.85 g 0.014 mol), THF (20 mL), 25 and 1.6 M n-butyl lithium in hexane (8.4 mL, 0.013 mol). The reaction was then warmed to 52°C for 5 h. The cooled reaction was acidified with dilute HCl and diluted with ether. the aqueous fraction was washed with ether, made basic, and extracted with ether. The extracts were dried and 30 evaporated to give a clear liquid. The HCl salt (1.4 g) crystallized from CHCl₃-EtOAc-ether, m.p. 186-188°C. (Compound 1).

EXAMPLE 2(+/-)-3-Chloro-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A solution of 1-azabicyclo[2.2.2]octan-3-ol (5 g,
5 0.039 mol) in THF (400 mL) was treated with 1.6 M n-
butyllithium in hexane (25 mL, 0.04 mol). After 1 h, the
solution was cooled in an ice-water bath and 2,3-
dichloropyrazine (6.6 g, 0.044 mol) in THF (30 mL) was added
in one portion. Cooling was removed and after 30 min., the
10 reaction was heated to reflux for 2.5 h. The solvent was
evaporated, the residue acidified with 1 N HCl, and the
mixture extracted with ether. The aqueous fraction was made
basic and extracted with ether. The extracts were washed
with water, dried, and the solvent evaporated to give a tacky
15 solid. Recrystallization from ether gave a yellow solid
(1.74 g), m.p. 112.5-114°C. (Compound 2).

EXAMPLE 3(+/-)-3-Butyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

20 A solution of sodium butyloxide (0.25 g Na, 0.0109
mol, 1-butanol, 30 mL) was added to (compound 2) (0.48 g,
0.002 mol), the reaction stirred overnight, then heated to
80°C for 4 h. The solution was acidified and the solvent
25 evaporated. The residue was suspended in H₂O, extracted with
ether, and the aqueous solution made basic. The aqueous
fraction was extracted with EtOAc, the extracts washed with
H₂O, dried, and the solvent evaporated to give a yellow oil.
The HCl salt (0.32 g) crystallized from EtOAc as a white
30 powder, m.p. 150-151°C. (Compound 3).

EXAMPLE 4(+/-)-3-Propyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

35 To a solution of lithium 1-propyloxide (7 mL 1.6 M
n-butyllithium, 0.011 mol, 1-propanol, 30 mL) was added
(compound 2) (0.63 g, 0.0026 mol) and the reaction heated to

reflux for 6 h. The solvent was evaporated, the residue suspended in H₂O, and the mixture extracted with EtOAc. The extracts were washed with H₂O, dried, and the solvent evaporated to give an oil. The HCl salt (0.34 g) crystallized from acetone as a tan solid, m.p. 186-190°C. (Compound 4).

EXAMPLE 5

(+/-)-3-Hexyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

10

To a solution of lithium 1-hexyloxide (7.8 mL 1.6 M n-butyllithium, 0.013 mol, 1-hexanol, 20 mL) was added (compound 2) (0.6 g, 0.0025 mol) and the reaction heated to 80°C overnight. The solution was cooled, treated with 1 N HCl (15 mL) and the solvent evaporated. The residue was suspended in H₂O, the mixture washed with ether, and made basic. The aqueous fraction was extracted with EtOAc, the extracts dried, and the solvent evaporated to give an oil. The HCl salt (0.34 g) crystallized from EtOAc as a hemihydrate, m.p. 162-164°C. (Compound 5).

15

20

EXAMPLE 6

(+/-)-3-Butylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

25

A solution of 1-butanethiol (1.1 mL) in THF (100 mL) was treated with 1.6 M n-butyl lithium in hexane (4.7 mL, 0.0075 mol). After 10 min, (compound 2) (0.6 g, 0.0025 mol) was added and the reaction heated to reflux for 3 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with ether. The ether was dried and the solvent evaporated to give a clear liquid. The HCl salt (0.59 g) crystallized from EtOAc as white crystals, m.p. 192-193°C (Compound 6).

30

35

EXAMPLE 7**(+/-)-3-Pentylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine**

A solution of 1-pentanethiol (1.2 mL) in THF (50 mL) was treated with 1.6 M n-butyl lithium in hexane (4.7 mL, 0.0075 mol). After 10 min, (compound 2) (0.6 g, 0.0025 mol) was added and the reaction heated to reflux for 2 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with ether. The aqueous was made basic and extracted with EtOAc. The EtOAc was dried and the solvent evaporated to give a clear liquid. The HCl salt (0.44 g) crystallized from EtOAc, m.p. 169-171°C (Compound 7).

15

EXAMPLE 8**(+/-)-2-(1-Azabicyclo[2.2.2]octyl-3-oxy)pyrazine**

A suspension of 60% NaH in oil (1 g, 0.025 mol) in DMF (30 mL) was treated with 1-azabicyclo[2.2.2]octan-3-ol (3.28 g, 0.025 mol) and the mixture heated to 50°C for 65 min. The mixture was treated dropwise with 2-chloropyrazine (3.16 g, 0.027 mol) and heating continued for 3 h. Heating was discontinued and the reaction stirred overnight. The solvent was evaporated, the residue treated with water, acidified, and extracted with ether. The extracts were dried, the solvent evaporated, and the residue purified by radial chromatography (30% MeOH-EtOAc-trace NH₄OH) to give an oil. The HCl salt (2.07 g) crystallized from MeOH-EtOAc, m.p. 256-258°C (Compound 8).

35

EXAMPLE 9

(+/-)-3-(1-Pentyloxy)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

5 To a solution of lithium 1-pentoxide (1.6 M *n*-butyllithium, 7.6 mL, 0.012 mol, 1-pentanol, 20 mL) was added (Compound 2) (0.58 g, 0.0024 mol) and the reaction heated to 90°C overnight. The solution was acidified and the solvent evaporated. The residue was suspended in H₂O, extracted with
10 ether, and the aqueous solution made basic. the aqueous fraction was extracted with EtOAc, the extracts washed with H₂O, dried, and the solvent evaporated to give an oil. The oil was purified by radial chromatography (10% EtOH-1% NH₄OH-CHCl₃) and the HCl salt (0.2 g) crystallized from EtOAc as a
15 white powder, m.p. 163-165°C (Compound 9).

EXAMPLE 10

20 (+/-)-3-Methoxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

To a solution of sodium methoxide (Na, 0.4 g, 0.0174 mol, methanol, 25 mL) was added (compound 2) (0.8 g, 0.0033 mol) and the reaction heated to reflux overnight. The
25 solvent was evaporated, the residue suspended in H₂O, and the mixture extracted with EtOAc. The extracts were dried, the solvent evaporated, and the residue purified by radial chromatography (10% EtOH-1% NH₄OH-CHCl₃). The HCl salt (0.34 g) crystallized from 2-propanol as a hemihydrate, m.p. 215-
30 218°C. (Compound 10).

EXAMPLE 11

(+/-)-3-Ethoxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

35 To a solution of sodium ethoxide (Na, 0.4 g, 0.0174 mol, ethanol, 25 mL) was added (compound 2) (0.8 g, 0.0033 mol) and the reaction heated to reflux overnight. The

solvent was evaporated, the residue suspended in H₂O, and the mixture extracted with EtOAc. The extracts were dried, the solvent evaporated, and the residue purified by radial chromatography (10% EtOH-1 % NH₄OH-CHCl₃). The HCl salt (0.086 g) crystallized from 2-propanol, m.p. 215-218°C. (Compound 11).

EXAMPLE 12

10 (+/-)-3-(1-Hexylthio)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A solution of 1-hexanethiol (1.4 mL) in THF (50 mL) was treated with 1.6 M n-butyllithium in hexane (4.7 mL, 0.0075 mol). After 10 min, (compound 2) (0.6 g, 0.0025 mol) was added and the reaction heated to reflux for 4 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with EtOAc. The EtOAc was dried and the solvent evaporated to give a clear liquid. The HCl salt (0.57 g) crystallized from EtOAc, m.p. 171-174°C (Compound 12).

EXAMPLE 13

25 (+/-)-3-Methylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A suspension of NaH (0.42 g, 0.018 mol) in DMF (25 mL) was treated with 5.19 M methanethiol in DMF (6.44 mL, 0.033 mol). After 10 min, (compound 2) (0.8 g, 0.0033 mol) was added and the reaction heated to 50°C for 3 h. The reaction was cooled, acidified, and the solvent evaporated. The residue was suspended in cold water, extracted with ether, the aqueous made basic, and the mixture extracted with EtOAc. The EtOAc was dried and the solvent evaporated to give a clear liquid. The HCl salt (0.63 g) crystallized from MeOH-EtOAc, m.p. 243-247°C. (Compound 13).

EXAMPLE 14

(+/-)-3-Ethylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A solution of ethanethiol (2.6 mL) in THF (90 mL) was treated with 1.6 M n-butyllithium in hexane (9 mL, 0.0167 mol). After 15 min, (compound 2) (0.6 g, 0.0025 mol) was added and the reaction heated to reflux for 4 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with EtOAc. The EtOAc was dried, the solvent evaporated, and the residue purified by radial chromatography (5% EtOH-0.5% NH₄OHCHCl₃). The HCl salt (0.48 g) crystallized from EtOAc, m.p. 269-272°C. (Compound 14).

EXAMPLE 15

(+/-)-3-(1-Propylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A solution of 1-propanethiol (2.7 mL) in THF (90 mL) was treated with 1.6 M n-butyllithium in hexane (7 mL, 0.0117 mol). After 15 min, (compound 2) (0.7 g, 0.0029 mol) was added and the reaction heated to reflux for 4 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with EtOAc. The EtOAc was dried, the solvent evaporated to give an oil. The HCl salt (0.76 g) crystallized from MeOH-EtOAc, m.p. 231-234°C. (Compound 15).

EXAMPLE 16

(+/-)-3-(1-Heptylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

A solution of 1-heptanethiol (4.9 mL) in THF (90 mL) was treated with 1.6 M n-butyllithium in hexane (7 mL, 0.0117 mol). After 15 min, (compound 2) (0.7 g, 0.0029 mol)

was added and the reaction heated to reflux for 4 h. The solvent was evaporated, the residue acidified with cold dilute HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with EtOAc. The EtOAc was dried, the solvent evaporated to give an oil. The HCl salt (0.767 g) crystallized from MeOH-EtOAc as a hemihydrate, m.p. 169-173°C. (Compound 16).

EXAMPLE 17

3-(1-Butylthio-2-(2-(dimethylamino)ethoxy)pyrazine

A solution of 2-dimethylaminoethanol (2.13 mL, 0.021 mol) in THF (130 mL) was treated with 1.6 M *n*-butyllithium in hexane (13.1 mL, 0.021 mol) with cooling in an ice-water bath. To the solution was added 2,3-dichloropyrazine (3.13 g, 0.021 mol) and the reaction heated to reflux overnight. The solvent was evaporated, the residue acidified with cold 1 N HCl, and the mixture extracted with ether. The aqueous was made basic and extracted with EtOAc. The extracts were washed with water, dried, and the solvent evaporated to give a clear oil (3.86 g). The oil was added to a solution of lithium 1-butanethioxide (1.6 M *n*-butyllithium, 17 mL, 0.0273 mol, 1-butanethiol, 19.7 mL, 0.184 mol) in THF (100 mL), the reaction heated to reflux for 2 h, heating removed, and the reaction stirred over the weekend. The solvent was evaporated, the residue dissolved in dilute HCl, and the mixture extracted with ether. The aqueous phase was made basic, extracted with EtOAc, the extracts dried, and the solvent evaporated. The residue was purified by radial chromatography (5% EtOH-0.5% NH₄OH-CHCl₃) to give an oil (3.4 g). The HCl salt crystallized from EtOAc to give a white solid, m.p. 120-123°C. (Compound 17).

EXAMPLE 18**3-(1-Butylthio)-2-(2-(trimethylamino)ethoxy)pyrazine iodide**

5 A solution of (compound 17) (0.7 g, 0.0028 mol) in EtOAc (40 mL) was treated with iodomethane (0.4 mL) and the reaction stirred overnight. The white solid (1.04 g) was collected by filtration and dried, m.p. 140-142°C. (Compound 18).

EXAMPLE 19**3-Chloro-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine**

15 A solution of potassium t-butoxide (0.62 g, 0.0055 mol) in THF (10 mL) was treated with endo-(+,-)-1-azabicyclo[3.2.1]octan-6-ol (0.64 g, 0.005 mol). After 5 min, 2,3-dichloropyrazine (2 g, 0.0134 mol) was added and the reaction stirred overnight. The reaction was diluted with
20 H₂O, acidified, and extracted with ether. The aqueous phase was made basic and extracted with EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The residue was purified by radial chromatography (20 % EtOH-2 % NH₄OH-CHCl₃) to give an oil. The HCl salt crystallized from
25 acetone (0.44 g), m.p. 200 °C dec. (Compound 19).

Example 20**3-Methyl-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine**

30 A solution of potassium t-butoxide (0.62 g, 0.0055 mol) in THF (10 mL) was treated with endo-(+,-)-1-azabicyclo[3.2.1]octan-6-ol (0.64 g, 0.005 mol). After 5 min, reaction was cooled in an ice-water bath and 2-chloro-3-methylpyrazine (1.3 g, 0.01 mol) was added in a single portion. Cooling was removed and the reaction stirred for 3

days. The solvent was evaporated, the residue diluted with H₂O, acidified, and extracted with ether. The aqueous phase was made basic and extracted with EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The residue was converted to an HCl salt and recrystallized from 2-propanol to give a flocculant powder (0.5 g), m.p. 240 °C dec. (Compound 20).

Example 21

10 2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

A solution of potassium t-butoxide (0.62 g, 0.0055 mol) in THF (10 mL) was treated with endo-(+,-)-1-azabicyclo[3.2.1]octan-6-ol (0.64 g, 0.005 mol). After 5 min, reaction was cooled in an ice-water bath and 2-chloro-3-methylpyrazine (1.2 g, 0.01 mol) was added in a single portion. Cooling was removed and the reaction stirred 4 h. The solvent was evaporated, the residue diluted with H₂O, acidified, and extracted with ether. The aqueous phase was made basic and extracted with EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The solid residue was converted to an HCl salt and recrystallized from 2-propanol to give a white solid (0.92 g), m.p. 250 °C dec. (Compound 21).

25

Example 22

6-Chloro-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

30 A solution of potassium t-butoxide (0.62 g, 0.0055 mol) in THF (10 mL) was treated with endo-(+,-)-1-azabicyclo[3.2.1]octan-6-ol (0.64 g, 0.005 mol). After 5 min, reaction was cooled in an ice-water bath and 2,6-dichloropyrazine (1 g, 0.0067 mol) was added in a single portion. Cooling was removed and the reaction stirred over night. The solvent was evaporated, the residue diluted with H₂O, acidified, and extracted with ether. The aqueous phase

was made basic and extracted with EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The residue was purified by radial chromatography (20 % EtOH-2 % NH₄OH-CHCl₃). The HCl salt crystallized from acetone to give
5 a white solid (0.33 g), m.p. 211-213 °C dec. (Compound 22).

Example 23

3-(1-butyloxy)-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

10

A solution of potassium t-butoxide (1 g, 0.0089 mol) in THF (20 mL) was treated with 1-butanol (1 mL). After 5 min, reaction was cooled in an ice-water bath and Compound 19 (0.65 g, 0.0027 mol) in THF (10 mL) was added. Cooling was
15 removed and the reaction stirred for 3 days. The solvent was evaporated, the residue diluted with H₂O, acidified, and extracted with ether. The aqueous phase was made basic and extracted with EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The residue was purified
20 by radial chromatography (20 % EtOH-2 % NH₄OH-CHCl₃). The HCl salt crystallized from EtOAc to give a white solid (0.23 g), m.p. 171.5-172.5 °C dec. (Compound 23)

Example 24

25

3-(1-butylthio)-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

A solution of potassium t-butoxide (1 g, 0.0089 mol) in THF (20 mL) was cooled in ice-water and treated with
30 1-butanethiol (1 mL). After 5 min, cooling was removed and Compound 19 (0.6 g, 0.0025 mol) in THF (10 mL) was added. After stirring overnight, the solvent was evaporated, the residue diluted with H₂O, acidified, and extracted with ether. The aqueous phase was made basic and extracted with
35 EtOAc, the extracts dried, washed with brine, dried, and the solvent evaporated. The residue was purified by radial chromatography (20 % EtOH-2 % NH₄OH-CHCl₃). The HCl salt

crystallized from EtOAc to give a white solid (0.64 g), m.p. 157-158 °C dec. (Compound 24).

Example 25

5

endo-(8-Methyl-8-azabicyclo[3.2.1]octyl-3-oxy)pyrazine

A solution of potassium tert-butoxide (0.62 g) in THF (15 mL) was treated with tropine (0.7 g). After 5 min, the reaction
10 was cooled in ice-water and chloropyrazine (1.2 g) was added. The cooling was removed and the reaction stirred over night. The solvent was evaporated, the residue dissolved in cold 1 N HCl, and the mixture extracted with ether. The aqueous fraction was made basic, extracted with EtOAc, the extracts
15 washed with water, brine, the solvent dried, and the solvent evaporated. The residue was purified by radial chromatography eluting with 20%-EtOH-2%-NH₄OH-CHCl₃ to give endo-(8-methyl-8-azabicyclo[3.2.1]octyl-3-oxy)pyrazine (0.6 g) that was isolated as a HCl salt that crystallized from 2-propanol, m.p. 240 °C, dec. (Compound 25).
20

Example 26

2-(2-Dimethylaminoethoxy)pyrazine

25

A solution of 2-dimethylaminoethanol (1 mL) in THF (20 mL) was treated with potassium tert-butoxide (1.2 g). After 5 min, chloropyrazine (2 g) was added and the reaction stirred 2 h. The solvent was evaporated, the residue suspended in
30 cold water, the mixture acidified, and the mixture extracted with ether. The aqueous fraction was made basic and extracted with EtOAc. The extracts were dried, the solvent evaporated, and the residue purified by radial chromatography eluting with 10%-EtOH-1%-NH₄OH-CHCl₃ to give 2-(2-dimethylaminoethoxy)pyrazine (1.3 g). The HCl salt
35 crystallized from 2-propanol as a white solid, m.p. 151-153 °C. (Compound 26).

Example 272-(2-Trimethylaminoethoxy)pyrazine iodide

5 A solution of the free base of Compound 26 (0.7 g) in EtOAc (40 mL) was treated with methyl iodide (1 mL) and the reaction stirred over night. The resulting solid was collected and dried to give 2-(2-trimethylaminoethoxy)pyrazine iodide as a off white solid
10 (1.34 g), m.p. 164 °C, dec. (Compound 27).

Example 28(S)-2-(1-Methyl-2-pyrrolidinylmethoxy)pyrazine

15 A solution of (S)-1-methyl-2-pyrrolidinemethanol (1.15 g) in THF (45 mL) was treated with potassium tert-butoxide (1.2 g). After 10 min, chloropyrazine was added and the reaction stirred for 1.5 h. The reaction was quenched with 5 N HCl (4
20 mL) and the solvent evaporated. The residue was suspended in water and extracted with ether. The aqueous fraction was made basic and extracted with CHCl₃. The extracts were dried, the solvent evaporated, and the residue purified by radial chromatography eluting with 20%-EtOH-2%-NH₄OH-CHCl₃ to
25 give (S)-2-(1-methyl-2-pyrrolidinylmethoxy)pyrazine (1.1). The HCl salt crystallized from EtOAc as a white solid, m.p. 121-122 °C. (Compound 28)

Example 29

30 (±)-endo-2-Propylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxo)pyrazine

Potassium t-butoxide (0.9 g, 8 mmoles) was added at 0° C. to
35 propanethiol (0.61 g, 8 mmoles) in 20 ml THF and stirred for 5 min. Compound 19 (0.5 g, 2 mmoles) was added and the reaction stirred for 24 hr at room temperature. 200 ml of 1 N

HCl was added and the aqueous solution washed with ethyl acetate. The pH was adjusted to 12.0. The product was extracted with ethyl acetate, dried over sodium sulfate and evaporated. The HCl salt was formed in ether and filtered to
5 yield (\pm)-endo-2-propylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine hydrochloride (0.38 g), m.p. 159-160 °C.
(Compound 29)

The following compounds were prepared in substantially the
10 same manner as Compound 29 by substituting the appropriate alkylthiol for propanethiol.

Example 30

15 (\pm)-endo-2-Pentylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and pentanethiol in 60% yield, m.p. 159-160 °C. (Compound 30).

20

Example 31

(\pm)-endo-2-(2-Methylpropylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

25

Obtained from Compound 19 and 2-methylpropanethiol in 8% yield, m.p. 142-143 °C. (Compound 31).

Example 32

30

(\pm)-endo-2-Ethylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and ethanethiol in 53% yield, m.p.
35 196-197 °C. (Compound 32).

Example 33

5 (±)-endo-2-(2,2,2-Trifluoroethylthio)-3-(1-
 azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and 2,2,2-trifluoroethanethiol in 14% yield, m.p. 116-117 °C. (Compound 33).

10 **Example 34**

(±)-endo-2-(trans-2-Butenylthio)-3-(1-azabicyclo[3.2.1]octyl-
 6-oxy)pyrazine

15 Obtained from Compound 19 and trans-2-butenethiol in 13% yield, m.p. 128-130 °C. (Compound 34).

Example 35

20 (±)-endo-2-(4,4,4-Trifluorobutylthio)-3-(1-
 azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and 4,4,4-trifluorobutanethiol in 30% yield, m.p. 173-174 °C. (Compound 35).

25

Example 36

(±)-endo-2-(2-propenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-
 oxy)pyrazine

30

Obtained from Compound 19 and 2-propenethiol in 70% yield, m.p. 254-255 °C. (Compound 36).

Example 37

5 (±)-endo-2-(3-Methylbutylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and 3-methylbutanethiol in 26% yield, m.p. 174-176 °C. (Compound 37).

10

Example 38

(±)-endo-2-(4-Trifluoromethoxybenzylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

15 Obtained from Compound 19 and 4-trifluoromethoxybenzylthiol in 57% yield, m.p. 175-176 °C. (Compound 38).

Example 39

20 (±)-endo-2-Propylthio-6-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 22 and propanethiol in 11% yield as a foam. (Compound 39).

25

Example 40

(±)-endo-2-(2,2,2-Trifluoroethylthio)-6-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

30

Obtained from Compound 22 and 2,2,2-trifluoroethanethiol in 7% yield, m.p. 125-126 °C. (Compound 40).

35

Example 41

(±)-endo-2-(2-Methoxyethylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

5 Compound 19 (1.15 g, 4.7 mmols) and sodium sulfide (Na₂S·9H₂O), 1.68 g, 7 mmols) were heated in 30 ml DMF at 50° C. for 3.5 hr, cooled to 0° C. and 2-Bromoethylmethylether (1.3 g, 9 mmols) added. The reaction
10 was stirred at room temperature overnight and diluted with ethyl acetate and 100 ml of 5 N HCl. The aqueous layer was washed with ethyl acetate and the pH adjusted to 12.0. The product was extracted with ethyl acetate, dried over sodium sulfate, condensed and purified by HPLC eluted with 94%CHCl₃/
15 5% ethanol/ 1% ammonium hydroxide. The HCl salt was formed in ether and filtered to give (±)-endo-2-(2-Methoxyethylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine hydrochloride (0.3 g), m.p. 165-166 °C. (Compound 41).

20

The following compounds were prepared in substantially the same manner as Compound 41 substituting the appropriate
25 alkylhalide for 2-bromoethylmethylether.

Example 42

(±)-endo-2-(3-Phenyl-2-propenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

30

Obtained from Compound 19 and cinnamyl bromide in 36% yield, m.p. 165-167 °C. (Compound 42).

Example 43

5 (±)-endo-2-(4-Methyl-3-pentenylthio)-3-(1-
 azabicyclo[3.2.1]octyl-6-oxy)pyrazine

Obtained from Compound 19 and 1-bromo-4-methyl-3-pentene in 8% yield as a foam. (Compound 43).

10

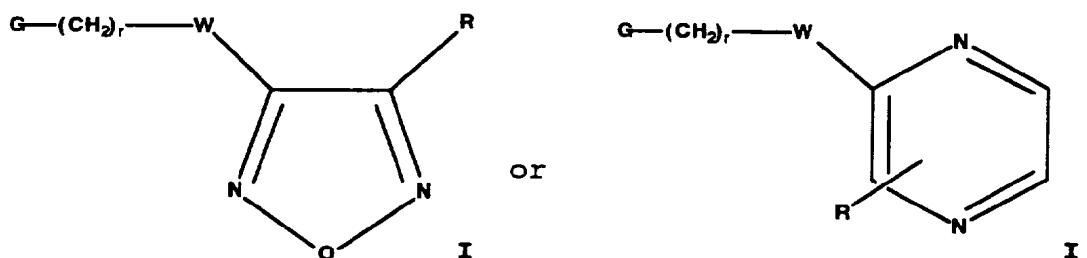
Example 44Alternate Synthesis of Compound 19

15 A sample of (±)-(endo)-1-Azabicyclo[3.2.1]octan-6-
ol (3.0 g, 23.6 mmols, was added to a stirred solution of
potassium t-butoxide (2.9 g, 26 mmols) in 60 ml THF at room
temperature. The reaction was cooled to 5 °C and 2,3-
dichloropyrazine (7.03 g, 47 mmols) in 15 ml THF was added.
The solution was stirred at room temperature for 2 hrs,
20 condensed, and diluted with water and ethyl acetate. The
organic solution was dried and condensed. Purification by
HPLC eluting with 94% CHCl₃, 5% ethanol, 1 % ammonium
hydroxide yielded 4.9 g, (Compound 19).

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Claims

1. A compound of Formula I or I' or the quaternized form thereof selected from the following:



wherein

W is oxygen or sulphur;

R is selected from the group consisting of hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-OR^4$, $-SR^4$, $-SOR^4$, $-SO_2R^4$, C_{3-10} -cycloalkyl, C_{4-12} -(cycloalkylalkyl), $-Z-C_{3-10}$ -cycloalkyl and $-Z-C_{4-12}$ -(cycloalkylalkyl); R^4 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of halogen(s), $-CF_3$, $-CN$, Y, phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or

R is selected from the group consisting of $-OR^5Y$, $-SR^5Y$, OR^5-Z-Y , $-SR^5ZY$, $-O-R^5-Z-R^4$ and $-S-R^5-Z-R^4$;

Z is oxygen or sulphur;

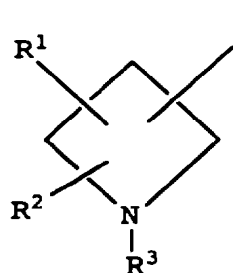
R^5 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl;

Y is a 5 or 6 membered heterocyclic group; and

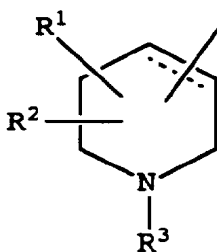
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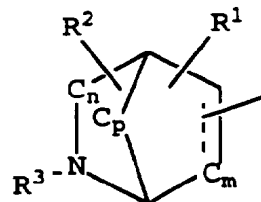
G is selected from one of the following azacyclic or azabicyclic ring systems:



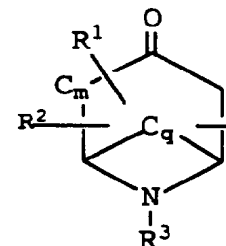
het-1



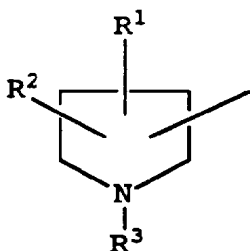
het-2



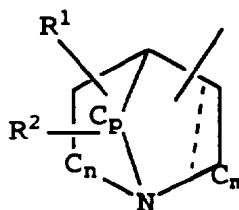
het-3



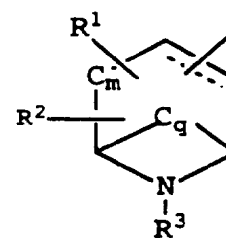
het-4



het-5



het-6



het-7

or G can optionally be substituted C₃-C₈ cycloalkyl or substituted C₁₋₆-alkyl wherein the substitution is -NR⁶R⁷; R⁶ and R⁷ independently are selected from the group consisting of hydrogen and C₁₋₆-alkyl; or R⁶ and R⁷ together with the nitrogen atom optionally form a 4- to 6-member ring;

R¹ and R² independently are selected from the group consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a substituent independently selected from the group consisting of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl; R³ is selected from the group consisting of hydrogen, C₁₋₅-alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and C₁₋₆-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

p is 0, 1 or 2;

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q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond;

provided that if the compound is Formula I'; W is O and G is a saturated azabicyclic group having from 7 to 11 ring carbon atoms and a nitrogen atom wherein the nitrogen atom is separated from the W atom by 2 to 3 ring carbon atoms; then R is selected from the group consisting of R⁴, -OR⁴, -SR⁴', SOR⁴', -SO₂R⁴', substituted phenyl or benzyloxycarbonyl wherein the substituents are one or more independently selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl);

R⁴ is selected from the group consisting of optionally substituted C₅₋₁₅-alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

R⁴ is substituted C_{1-C4} alkyl wherein the substituent is selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂;

R⁴' is selected from the group consisting of optionally substituted C_{1-C15} alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

R is phenyl which is substituted with -CN, -OCF₃, -CONH₂ or -CSNH₂; or

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R is $-OR^5Y$, $-SR^5Y$, OR^5-Z-Y , $-SR^5ZY$, $-O-R^5-Z-R^4$ or $-S-R^5-Z-R^4$; or

R is benzyloxycarbonyl, each of which is optionally substituted with halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ or $-CSNH_2$; and

further provided that if the compound is Formula I'; R is H, W is O, r is 1, R^1 and R^2 are each selected from hydrogen and C_1-C_6 alkyl; and

the I' group is attached to the G substituent α to the N atom in the G substituent; and --- is not a double bond;

then G is selected from the group consisting of het-4, het-7, het-6 wherein $n=2$; het-3 wherein one of n and m is 0 or 2; and het-3 wherein I' is attached to het-3 at the bridgehead of G; or

if R is H, W is O, r is 1, R^2 and R^3 are each selected from hydrogen and C_1-C_6 alkyl; the I' group is attached to the G substituent α to the N atom in the G substituent; and --- is not a double bond;

and G is het-5, and at least one of R^1 and R^2 is selected from hydrogen and alkyl and one of R^1 and R^2 is in position 4 of the G substituent, then the R^1 or R^2 substituent at the 4 position of the G substituent is selected from the group consisting of C_2-C_5 alkenyl, C_8-15 -alkyl, C_{2-5} -alkynyl, and C_{1-5} -alkyl substituted with a substituent independently selected from the group consisting of $-OH$, $-COR^6$, CH_2-OH , halogen, $-NH_2$, carboxy, and phenyl; or

if R is H, W is O, r is 1, R^1 and R^2 are each selected from hydrogen and C_1-C_6 alkyl; the I' group is attached to the G substituent at the 2 position of the G substituent; and --- is not a double bond; and G is het-5 and R^1 and R^2 are each hydrogen then R^3 is selected from the group consisting of C_{2-5} -alkenyl and C_{2-5} -alkynyl;

or a pharmaceutically acceptable salt or solvate thereof.

2. A compound of Claim 1 wherein W is S.

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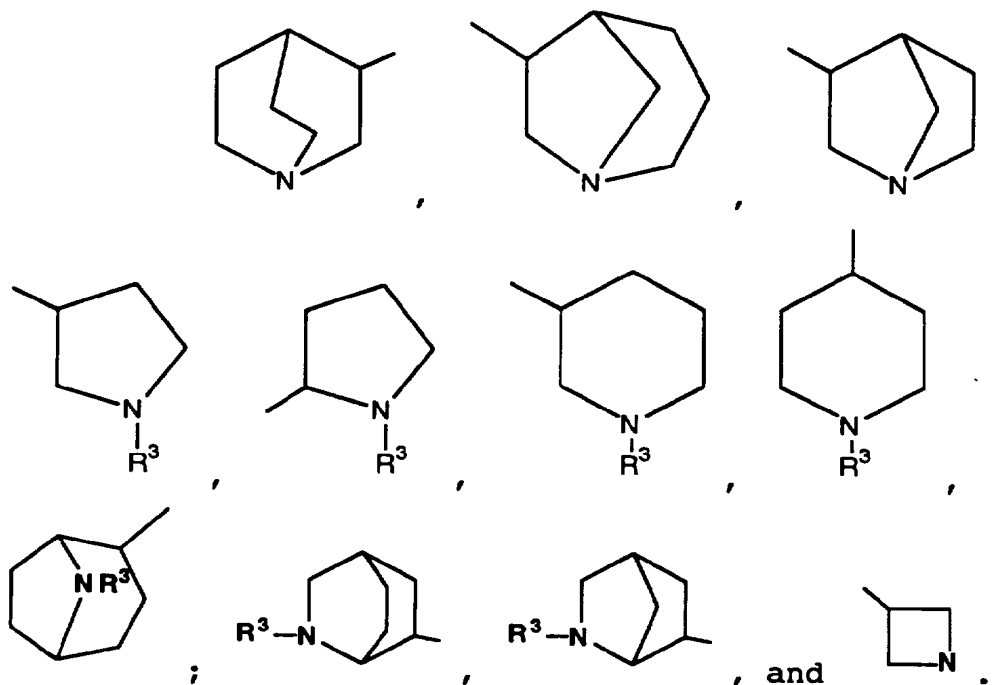
3. A compound of **Claim 1** wherein W is O; G is an azacycle.

4. A compound of **Claim 3** wherein the compound is a compound of Formula I.

5. A compound of **Claim 3** wherein the compound is a compound of Formula I'.

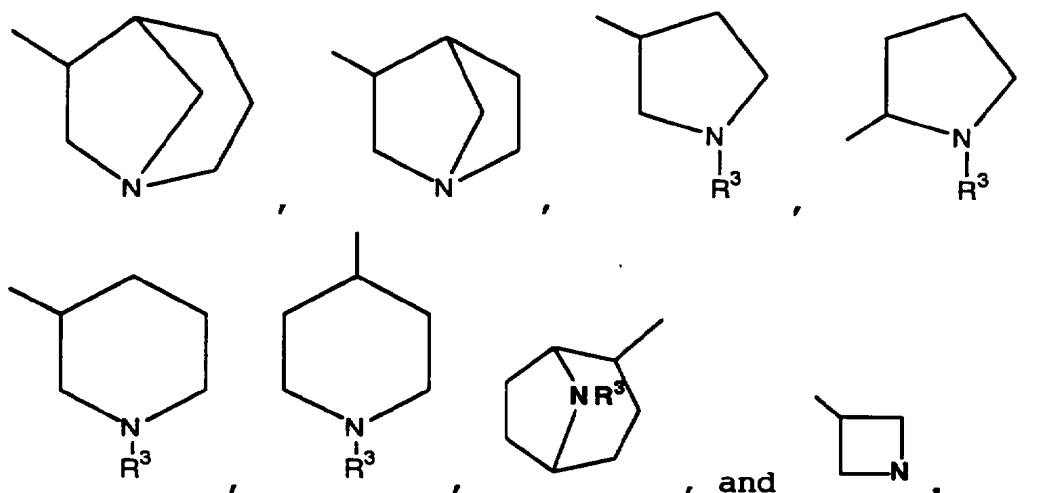
6. A compound of **Claim 2** wherein r is 1 or 2.

7. A compound of **Claim 1** wherein G is selected from the group consisting of:



8. A compound of **Claim 7** wherein G is selected from the group consisting of

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9. A compound of **Claim 1** which is selected from the following:

(±)-3-Butyloxy-4-(1-azabicyclo[2.2.2]octyl-3-oxy)-1,2,5-oxadiazole

(±)-3-Chloro-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Butyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Propyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Hexyloxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Butylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Pentylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-2-(1-Azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-(1-Pentyloxy)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(±)-3-Methoxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

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(\pm)-3-Ethoxy-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(\pm)-3-(1-Hexylthio)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(\pm)-3-Methylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(\pm)-3-Ethylthio-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(\pm)-3-(1-Propylthio)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

(\pm)-3-(1-Heptylthio)-2-(1-azabicyclo[2.2.2]octyl-3-oxy)pyrazine

3-Chloro-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

3-Methyl-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

6-Chloro-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

3-(1-butylthio)-2-[endo-(+,-)-6-(1-azabicyclo[3.2.1]octyloxy)]-pyrazine

or a pharmaceutically acceptable salt or solvate thereof.

10. A compound of **Claim 1** wherein the compound is selected from the group consisting of

(\pm)-endo-2-Propylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

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(±)-endo-2-Pentylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(2-Methylpropylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-Ethylthio-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(2,2,2,-Trifluoroethylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(trans-2-Butenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(4,4,4-Trifluorobutylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(2-propenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(3-Methylbutylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(4-Trifluoromethoxybenzylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-Propylthio-6-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(2,2,2-Trifluoroethylthio)-6-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(2-Methoxyethylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

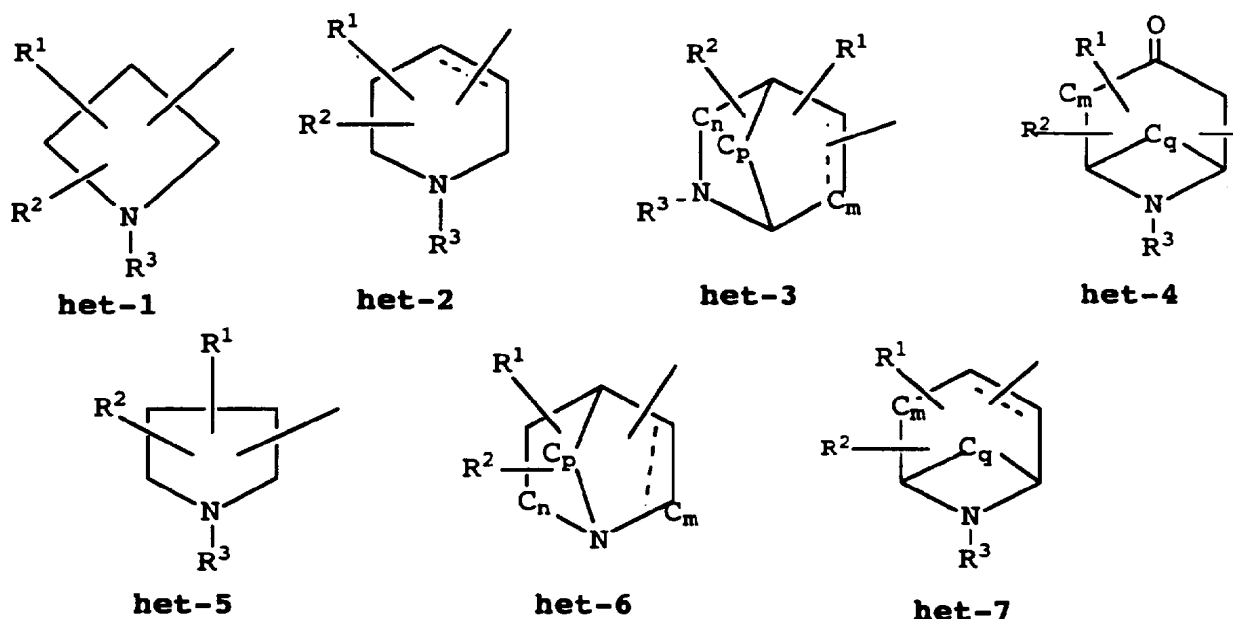
-61-

(±)-endo-2-(3-Phenyl-2-propenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

(±)-endo-2-(4-Methyl-3-pentenylthio)-3-(1-azabicyclo[3.2.1]octyl-6-oxy)pyrazine

11. A compound of Claim 1 wherein the compound is of Formula I
wherein W is oxygen or sulphur;
R is selected from the group consisting of hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-\text{OR}^4$, $-\text{SR}^4$, $-\text{SOR}^4$, $-\text{SO}_2\text{R}^4$, $\text{C}_3\text{-}_{10}$ -cycloalkyl, $\text{C}_4\text{-}_{12}$ -(cycloalkylalkyl), $-\text{Z-C}_3\text{-}_{10}$ -cycloalkyl and $-\text{Z-C}_4\text{-}_{12}$ -(cycloalkylalkyl); R^4 is selected from the group consisting of $\text{C}_1\text{-}_{15}$ -alkyl, $\text{C}_2\text{-}_{15}$ -alkenyl, and $\text{C}_2\text{-}_{15}$ -alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of halogen(s), $-\text{CF}_3$, $-\text{CN}$, Y, phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, $-\text{CN}$, $\text{C}_1\text{-}_4$ -alkyl, $\text{C}_1\text{-}_4$ -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or
R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, $-\text{CN}$, $\text{C}_1\text{-}_4$ -alkyl, $\text{C}_1\text{-}_4$ -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or
R is selected from the group consisting of $-\text{OR}^5\text{Y}$, $-\text{SR}^5\text{Y}$, $\text{OR}^5\text{-Z-Y}$, $-\text{SR}^5\text{ZY}$, $-\text{O-R}^5\text{-Z-R}^4$ and $-\text{S-R}^5\text{-Z-R}^4$;
Z is oxygen or sulphur;
 R^5 is selected from the group consisting of $\text{C}_1\text{-}_{15}$ -alkyl, $\text{C}_2\text{-}_{15}$ -alkenyl, and $\text{C}_2\text{-}_{15}$ -alkynyl;
Y is a 5 or 6 membered heterocyclic group; and
G is selected from one of the following azacyclic or azabicyclic ring systems:

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or G can optionally be substituted C₃-C₈ cycloalkyl or optionally substituted C₁₋₆-alkyl wherein the substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are selected from the group consisting of hydrogen and C₁₋₆-alkyl; or R⁶ and R⁷ together with the nitrogen atom optionally form a 4- to 6-member ring;

R¹ and R² independently are selected from the group consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a substituent independently selected from the group consisting of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl; R³ is selected from the group consisting of hydrogen, C₁₋₅-alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and C₁₋₆-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

p is 0, 1 or 2;

q is 1 or 2;

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r is 0, 1 or 2;

..... is a single or double bond;

provided that when W is O and G is a saturated azabicyclic group having from 7 to 11 ring carbon atoms and a nitrogen atom wherein the nitrogen atom is separated from the W atom by 2 to 3 ring carbon atoms; then R is selected from the group consisting of R⁴, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl) wherein R⁴ is selected from the group consisting of optionally substituted C₅₋₁₅-alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

R⁴ is substituted C₁₋₄ alkyl wherein the substituent is selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂;

R is phenyl which is substituted with -CN, -OCF₃, -CONH₂ or -CSNH₂; or

R is -OR⁵Y, -SR⁵Y, OR⁵-Z-Y, -SR⁵ZY, -O-R⁵-Z-R⁴ or -S-R⁵-Z-R⁴; or

R is benzyloxycarbonyl, each of which is optionally substituted with halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ or -CSNH₂;

or a pharmaceutically acceptable salt or solvate thereof.

12. A compound of Claim 1 wherein the compound is of Formula I'

wherein W is oxygen or sulphur;

R is selected from the group consisting of hydrogen, amino, halogen, NHR⁶, NR⁶R⁷, R⁴, -OR⁴, -SR⁴, -SOR⁴, -SO₂R⁴, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl); R⁴ is selected from the group

consisting of C₁₋₁₅-alkyl, C₂₋₁₅-alkenyl, and C₂₋₁₅-alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

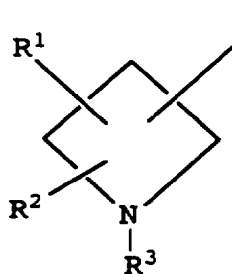
R is selected from the group consisting of -OR⁵Y, -SR⁵Y, OR⁵-Z-Y, -SR⁵ZY, -O-R⁵-Z-R⁴ and -S-R⁵-Z-R⁴;

Z is oxygen or sulphur;

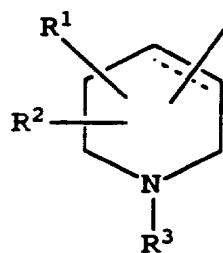
R⁵ is selected from the group consisting of C₁₋₁₅-alkyl, C₂₋₁₅-alkenyl, and C₂₋₁₅-alkynyl;

Y is a 5 or 6 membered heterocyclic group; and

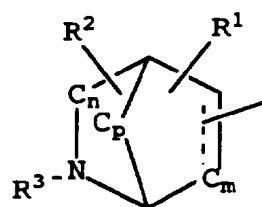
G is selected from one of the following azacyclic or azabicyclic ring systems:



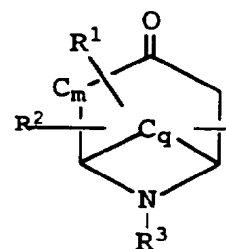
het-1



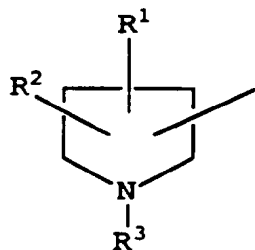
het-2



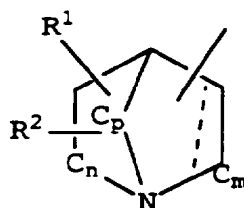
het-3



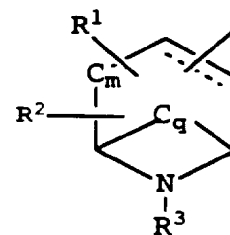
het-4



het-5



het-6



het-7

-65-

or G can optionally be substituted C₃-C₈ cycloalkyl wherein the substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are selected from the group consisting of hydrogen and C₁₋₆-alkyl; or

R⁶ and R⁷ together with the nitrogen atom optionally form a 4- to 6-member ring;

R¹ and R² independently are selected from the group consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a substituent independently selected from the group consisting of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl;

R³ is selected from the group consisting of hydrogen, C₁₋₅-alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and C₁₋₆-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

p is 0, 1 or 2;

q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond;

provided that when W is O and G is a saturated azabicyclic group having from 7 to 11 ring carbon atoms and a nitrogen atom wherein the nitrogen atom is separated from the W atom by 2 to 3 ring carbon atoms;

then R is selected from the group consisting of R⁴, -OR⁴, -SR^{4'}, SOR^{4'}, -SO₂R^{4'}, substituted phenyl or

benzyloxycarbonyl wherein the substituents are one or more independently selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl);

R⁴ is selected from the group consisting of optionally substituted C₅₋₁₅-alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl

-66-

and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

R⁴ is substituted C₁-C₄ alkyl wherein the substituent is selected from the group consisting of -CN, -OCF₃, -CF₃, -CONH₂ and -CSNH₂;

R^{4'} is selected from the group consisting of optionally substituted C₁-C₁₅ alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or more independently selected from the group consisting of halogen(s), -CF₃, -CN, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ and -CSNH₂; or

R is phenyl which is substituted with -CN, -OCF₃, -CONH₂ or -CSNH₂; or

R is -OR⁵Y, -SR⁵Y, OR⁵-Z-Y, -SR⁵ZY, -O-R⁵-Z-R⁴ or -S-R⁵-Z-R⁴; or

R is benzyloxycarbonyl, each of which is optionally substituted with halogen, -CN, C₁₋₄-alkyl, C₁₋₄-alkoxy, -OCF₃, -CF₃, -CONH₂ or -CSNH₂; and

further provided that if R is H, W is O, r is 1, R¹ and R² are each selected from hydrogen and C₁-C₆ alkyl; and

the I' group is attached to the G substituent α to the N atom in the G substituent; and --- is not a double bond;

then G is selected from the group consisting of het-4, het-7, het-6 wherein n=2; het-3 wherein one of n and m is 0 or 2;

and het-3 wherein the I' group is attached to het-3 at the bridgehead of the G substituent; or

if R is H, W is O, r is 1, R² and R³ are each selected from hydrogen and C₁-C₆ alkyl; the I' group is attached to the G substituent α to the N atom in the G substituent; and --- is not a double bond;

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and G is het-5, and at least one of R¹ and R² is selected from hydrogen and alkyl and one of R¹ and R² is in position 4 of the G substituent, then the R¹ or R² substituent at the 4 position of the G substituent is selected from the group consisting of C₂-C₅ alkenyl, C₈₋₁₅-alkyl, C₂₋₅-alkynyl, and C₁₋₅-alkyl substituted with a substituent independently selected from the group consisting of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl; or if R is H, W is O, r is 1, R¹ and R² are each selected from hydrogen and C₁-C₆ alkyl; the I' group is attached to the G substituent α to the N atom in the G substituent; and --- is not a double bond; and G is het-5 and R¹ and R² are each hydrogen then R³ is selected from the group consisting of C₂₋₅-alkenyl and C₂₋₅-alkynyl; or a pharmaceutically acceptable salt or solvate thereof.

13. A compound of **Claim 12** wherein G is selected from the group consisting of het-4, het-7, het-6 wherein n=2; het-3 wherein one of n and m is 0 or 2.

14. A compound of **Claim 12** whererin R is selected from the group consisting of C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl).

15. A compound of **Claim 12** wherein R is selected from the group consisting of R⁴, -OR⁴, SOR^{4'}, -SO₂R^{4'}, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl).

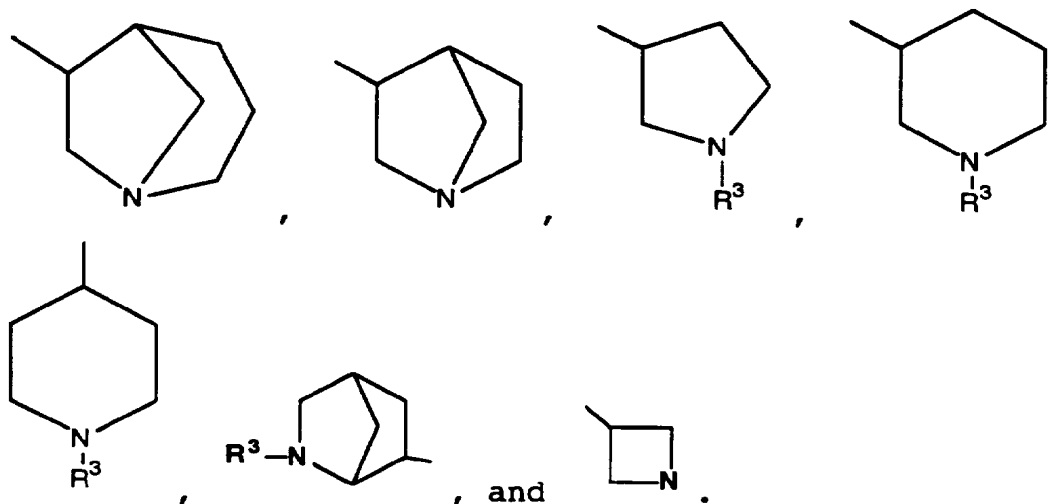
16. A compound of **Claim 12** wherein R is selected from the group consisting of R⁴, C₃₋₁₀-cycloalkyl, C₄₋₁₂-(cycloalkylalkyl), -Z-C₃₋₁₀-cycloalkyl and -Z-C₄₋₁₂-(cycloalkylalkyl); and R⁴ is selected from the group consisting of substituted C₅₋₁₅-alkyl, optionally substituted C₂₋₁₅-alkenyl, and optionally substituted C₂₋₁₅-alkynyl, wherein such substituent is one or

-68-

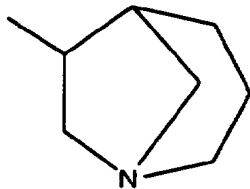
more independently selected from the group consisting of halogen(s), $-\text{CF}_3$, $-\text{CN}$, Y, phenyl and phenoxy; wherein phenyl or phenoxy is optionally substituted with one or more substituents selected from the group consisting of halogen, $-\text{CN}$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$.

17. A compound of **Claim 19** wherein R is selected from the group consisting of $-\text{SR}^{4'}$, $\text{SOR}^{4'}$, $-\text{SO}_2\text{R}^{4'}$, substituted benzyloxycarbonyl wherein the substituents are one or more independently selected from the group consisting of $-\text{CN}$, $-\text{OCF}_3$, $-\text{CF}_3$, $-\text{CONH}_2$ and $-\text{CSNH}_2$; or C_{3-10} -cycloalkyl, C_{4-12} -(cycloalkylalkyl), $-\text{Z}-\text{C}_{3-10}$ -cycloalkyl and $-\text{Z}-\text{C}_{4-12}$ -(cycloalkylalkyl).

18. A compound of **Claim 1** wherein G is selected from the group consisting of



19. A compound of **Claim 1** wherein G is

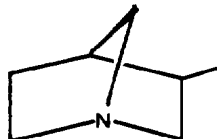


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20. A compound of **Claim 1** wherein the compound is Formula I.

21. A compound of **Claim 1** wherein the compound is Formula I'.

22. A compound of **Claim 1** wherein G is



23. A compound of **Claim 1** wherein the compound is *exo*.

24. A compound of **Claim 1** wherein G is *het-3* and I or I' is attached to G at the bridgehead of the G substituent.

25. A compound of **Claim 1** wherein G is a 2-aza substituent wherein the point of attachment of the I or I' group is β to the N atom in the G group.

26. A compound of **Claim 1** wherein G is a 3.2.1 substituent wherein the point of attachment of the I or I' group is β to the N atom in the G group.

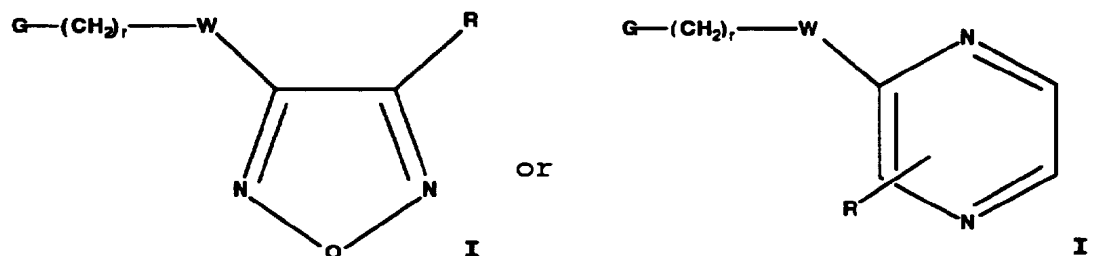
27. A pharmaceutical formulation comprising as an active ingredient a compound as claimed in anyone of **Claims 1 to 26** associated with one or more pharmaceutically acceptable carriers or diluents therefor.

28. A compound as claimed in any one of **Claims 1 to 26** and claims to or a pharmaceutically acceptable salt thereof for use in treating a condition associated with the modulation of a muscarinic cholinergic receptor.

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29. A compound as claimed in any one of Claims 1 to 26 and claims to or a pharmaceutically acceptable salt thereof for use in interacting with a muscarinic cholinergic receptor.

30. A compound of Formula I or I' or the quaternized form thereof selected from the following:



wherein

W is oxygen or sulphur;

R is selected from the group consisting of hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-OR^4$, $-SR^4$, $-SOR^4$, $-SO_2R^4$, C_{3-10} -cycloalkyl, C_{4-12} -(cycloalkylalkyl), $-Z-C_{3-10}$ -cycloalkyl and $-Z-C_{4-12}$ -(cycloalkylalkyl); R^4 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of

halogen(s), $-CF_3$, $-CN$, Y , phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or

R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or

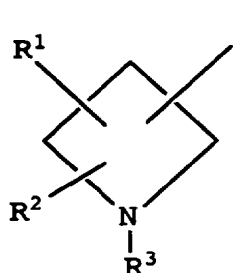
R is selected from the group consisting of $-OR^5Y$, $-SR^5Y$, OR^5-Z-Y , $-SR^5ZY$, $-O-R^5-Z-R^4$ and $-S-R^5-Z-R^4$;

Z is oxygen or sulphur;

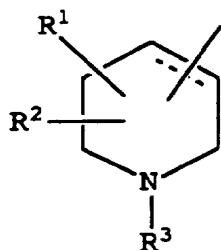
R^5 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl;

-71-

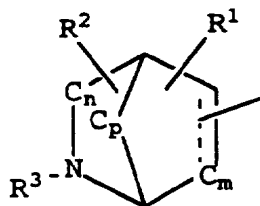
Y is a 5 or 6 membered heterocyclic group; and
G is selected from one of the following azacyclic or
azabicyclic ring systems:



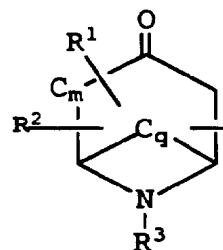
het-1



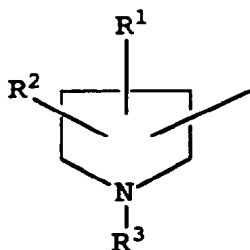
het-2



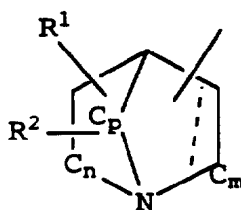
het-3



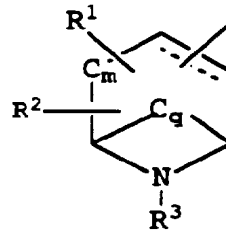
het-4



het-5



het-6



het-7

or G is optionally substituted C₃-C₈ cycloalkyl wherein the
substitution is -NR⁶R⁷;

R⁶ and R⁷ independently are selected from the group
consisting of hydrogen and C₁₋₆-alkyl; or R⁶ and R⁷ together
with the nitrogen atom optionally form a 4- to 6-member
ring;

R¹ and R² independently are selected from the group
consisting of hydrogen, C₁₋₁₅-alkyl, C₂₋₅-alkenyl, C₂₋₅-
alkynyl, C₁₋₁₀-alkoxy, and C₁₋₅-alkyl substituted with a
substituent independently selected from the group consisting
of -OH, -COR^{6'}, CH₂-OH, halogen, -NH₂, carboxy, and phenyl;
R³ is selected from the group consisting of hydrogen, C₁₋₅-
alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and
C₁₋₆-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

SUBSTITUTE SHEET (RULE 26)

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p is 0, 1 or 2;

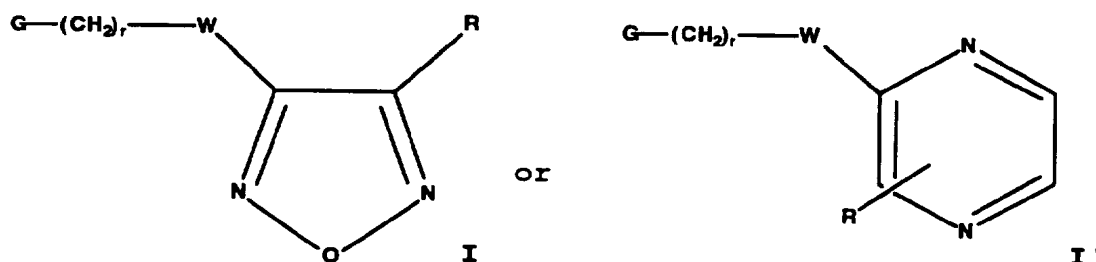
q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond;

provided that if the compound is Formula I' then R is not hydrogen or if R is hydrogen, then r is not 1; for use in treating a disease or disorder of the central nervous system caused by or related to malfunctioning of the nicotinic receptor system..

31. A compound of Formula I or I' or the quaternized form thereof selected from the following:



wherein

W is oxygen or sulphur;

R is selected from the group consisting of hydrogen, amino, halogen, NHR^6 , NR^6R^7 , R^4 , $-OR^4$, $-SR^4$, $-SOR^4$, $-SO_2R^4$, C_{3-10} -cycloalkyl, C_{4-12} -(cycloalkylalkyl), $-Z-C_{3-10}$ -cycloalkyl and $-Z-C_{4-12}$ -(cycloalkylalkyl); R^4 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl, each of which is optionally substituted with one or more independently selected from the group consisting of halogen(s), $-CF_3$, $-CN$, Y, phenyl and phenoxy wherein phenyl or phenoxy is optionally substituted with one or more selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or R is phenyl or benzyloxycarbonyl, each of which is optionally substituted with one or more substituents independently selected from the group consisting of halogen, $-CN$, C_{1-4} -alkyl, C_{1-4} -alkoxy, $-OCF_3$, $-CF_3$, $-CONH_2$ and $-CSNH_2$; or

SUBSTITUTE SHEET (RULE 26)

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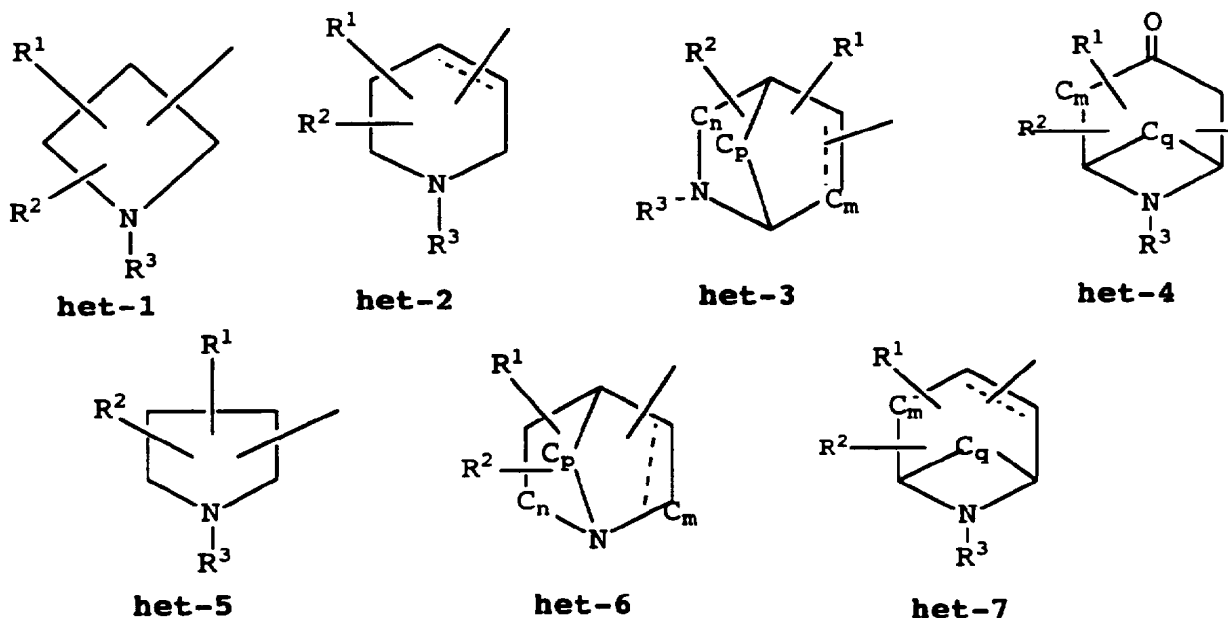
R is selected from the group consisting of $-OR^5Y$, $-SR^5Y$, OR^5-Z-Y , $-SR^5ZY$, $-O-R^5-Z-R^4$ and $-S-R^5-Z-R^4$;

Z is oxygen or sulphur;

R^5 is selected from the group consisting of C_{1-15} -alkyl, C_{2-15} -alkenyl, and C_{2-15} -alkynyl;

Y is a 5 or 6 membered heterocyclic group; and

G is selected from one of the following azacyclic or azabicyclic ring systems:



or G is optionally substituted C_3-C_8 cycloalkyl wherein the substitution is $-NR^6R^7$;

R^6 and R^7 independently are selected from the group consisting of hydrogen and C_{1-6} -alkyl; or R^6 and R^7 together with the nitrogen atom optionally form a 4- to 6-member ring;

R^1 and R^2 independently are selected from the group consisting of hydrogen, C_{1-15} -alkyl, C_{2-5} -alkenyl, C_{2-5} -alkynyl, C_{1-10} -alkoxy, and C_{1-5} -alkyl substituted with a substituent independently selected from the group consisting of $-OH$, $-COR^6'$, CH_2-OH , halogen, $-NH_2$, carboxy, and phenyl;

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R³ is selected from the group consisting of hydrogen, C₁₋₅-alkyl, C₂₋₅-alkenyl and C₂₋₅-alkynyl;

R^{6'} is selected from the group consisting of hydrogen and C₁₋₆-alkyl;

n is 0, 1 or 2;

m is 0, 1 or 2;

p is 0, 1 or 2;

q is 1 or 2;

r is 0, 1 or 2;

..... is a single or double bond;

provided that if the compound is Formula I' then R is not hydrogen; or if R is hydrogen then r is not 1 for interacting with a nicotinic receptor.

32. A method of treating a disease in the central nervous system caused by malfunctioning of the muscarinic cholinergic system comprising administering to a subject in need thereof a pharmaceutically effective amount of any one of Claims 1 to 26.

33. A method for treating a condition associated with the modulation of a nicotinic receptor comprising administering to a subject in need thereof a pharmaceutically effective amount of a compound of Claim 30.

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/13735

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : 548/125; 544/408; 546/133, 137, 112, 183, 209; 514/252, 253, 299, 305, 326, 364

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 548/125; 544/408; 546/133, 137, 112, 183, 209; 514/252, 253, 299, 305, 326, 364

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE, APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 5,043,345 (SAUERBERG ET AL) 27 August 1991, see columns 3 and 4.	1-4, 6-8, 11, 18, 20, 27-32
X	Chemical Abstracts, Volume 117, Number 13, issued 28 September 1992, Shoda et al, "Preparation of Amino-methylenebisphosphonates as Bone Resorption Inhibitors", page 766, abstract no. 117:131387, EP 491374 (Takeda Chemical Industries, Ltd., Japan) 24 June 1992, see the chemical with RN 143340-91-4.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

08 JANUARY 1996

Date of mailing of the international search report

06 FEB 1996

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
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Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

King L. Wong

Telephone No. (703) 308-1235

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/13735

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Chemical Abstracts, Volume 117, Number 3, issued 20 July 1992, Buschauer et al, "Synthesis and Histamine H2-Receptor Activity of Heterocyclic Impromidine Analogs", page 702, abstract no. 117:26428, Pharmazie, 47(2), pages 86-91, see the chemical with RN 141995-58-6.	1, 2
X	Chemical Abstracts, Volume 109, Number 21, issued 21 November 1988, Tarrago et al, "Synthesis and Ionophore Properties of a Series of New Tetrapyrazolic Macrocycles", page 712, abstract no. 109:190381, Tetrahedron, 44(1), pages 91-100, see the chemical with RN 117156-54-4.	1
X	Chemical Abstracts, Volume 106, Number 3, issued 09 January 1987, Barlin et al, "Heterocyclic Amplifiers of Phleomycin. X. Derivatives of Diazine Mono- and Dithiols", page 601. abstract no. 106:18488, Aust. J. Chem., 39(1), pages 69-75, see chemicals with RN 105759-01-1, 105759-03-3, 105759-07-7, 105759-11-3, 105759-22-6, 105759-23-7, or 105759-12-4.	1, 2
X	Chemical Abstracts, Volume 84, Number 19, issued 10 May 1976, Jaeggi et al, "Cyclic Substituted Derivatives of 1-Amino-2-propanol", page 482, abstract no. 84:135479, DE 2,520,910 (Ciba-Geigy A.-G., Switz.) 04 December 1975, see the chemical with RN 58756-96-0.	1
X	US, A, 4,894,453 (YASO ET AL) 16 January 1990, see column 1, line 40 to column 2, line 45.	1,3,5,11,27
X	WO, A, 94/08992 (ABBOTT LABORATORIES) 28 April 1994, see page-8 to page 11.	1,3,5,7,8, 11-13,18, 21,27,30, 31,33

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/13735

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-33 (in part)
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐

The additional search fees were accompanied by the applicant's protest.

☐

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/13735

A. CLASSIFICATION OF SUBJECT MATTER: IPC (6):

C07D 271/08, 413/12, 413/14, 241/14, 401/12, 401/14, 403/12, 403/14; A61K 31/41, 31/445, 31/55, 31/495

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-9, 11, 17-20, 22-29, and 32, drawn to compounds and compositions of Formula I, and their methods of use directed to the muscarinic cholinergic system.

Group II, claim(s) 1-9, 11, 17-20, 22-27, 30, 31, and 33, drawn to compounds and compositions of Formula I, and their methods of use directed to the nicotinic receptor.

Group III, claim(s) 1-10, 12-19, 21-29, and 32, drawn to compounds and compositions of Formula I', and their methods of use directed to the muscarinic cholinergic system.

Group IV, claim(s) 1-10, 12-19, 21-27, 30, 31, and 33, drawn to compounds and compositions of Formula I', and their methods of use directed to the nicotinic receptor.

The inventions listed as Groups I-IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

the special technical features of the inventions in Groups I and II are oxadiazoles, while the special technical features of the inventions in Groups III and IV are pyrazines. The oxadiazoles of Groups I and II do not share a significant structural element with the pyrazines of Groups III and IV and these oxadiazoles and pyrazines are not a class of compounds recognized in the art to be equivalent. The invention of Group I differs from that of Group II in the method of use. A product and one method of using the product belong to a single general inventive concept, so the oxadiazoles and the method of using the oxadiazoles directed toward the muscarinic cholinergic system belong to a single general inventive concept. However, the oxadiazoles and the method of using the oxadiazoles directed toward the nicotinic receptor belong to another general inventive concept. Similarly, the inventions of Groups III and IV are two separate general inventive concepts due to two different methods of use: the method of using pyrazines directed toward the muscarinic cholinergic system versus the nicotinic receptor.